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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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The Value of Technical Education.

Throughout Great Britain a thousand or so embryonic foundrymen are making up their minds whether or not they will join the foundry technical classes which now are organised for their benefit.

Some, in their ignorance, criticise the curriculum put forward, asserting that it is either too practical or too theoretical, forgetting that in nine out of ten cases, that if the students are capable, they are in a position to modify these courses according to their own needs; but until they have proved themselves to be enthusiastic, the principal obviously takes it for granted that he and his advisory committee knew better.

The greatest advantage of a technical education is that it gives the right to apply for positions which, from their very nature, exclude the untrained, and, further, it enhances the chance of winning positions in the commercial world when in competition with the non-technical aspirant.

When a student has qualified he is often of opinion that he has more technical knowledge than those who direct him. This may be correct, but the student has probably failed to realise that his chief's technical work occupies, maybe, only five to ten per cent. of his time, though an essential. What about the other 90 to 95 per cent.? Labour troubles may, for many consecutive days, occupy all his time. How would the student tackle these problems? His answer, "Commonsense," does not apply. *It is personality*—the most potent factor in business life. Why is it that a man, having the best of technical qualifications, does not get the best of jobs? Merely because he lacks this very qualification. This, too, is why the employer, manager or foreman insists on a personal interview, otherwise the suitability of men for jobs could be worked out mathematically by the mere filling up of suitable forms.

This leaves us to tell the young foundrymen how to acquire "personality." Unfortunately, if the germs are not present, the passing of examinations cannot bestow it; but personality *is developed* by the possession of specialised knowledge. Therefore, from this essential point of view, there is the pressing need for technical instruction, which it is desirable to supplement by a close study of allied subjects.

Trade conditions have been such that many young persons have had to enter a competition for which their training has ill-fitted them—that is, the competition of securing the few berths which have been vacant. We appeal to the many technical teachers to devote at least one evening to instructing the students how to put their qualifications into a concise and readable form. They should point out to them that there are other jobs available besides those advertised. The paragraphs which appear in the foundry press from time to time of new companies being formed and of extensions to existing ones, all provide possibilities of vacancies. Again, notices often appear of some firm having received orders for ships, locomotives, large electrical plant, and the like, which obviously contain possibilities. This not merely applies to evening students, but to those leaving the modern universities with a degree or diploma. We have seen applications for positions from this type of individual which show a very poor appreciation of what a prospective employer expects to see. By giving the students advice on such matters the lecturers will early make the student realise the value of technical education.

Teachers in close touch with large foundry proprietors would do well to impress upon the management the advisability of an annual individual talk to the apprentices by a director, the works manager, chief salesman, and other important executive officers. Even if this did take up several days of valuable time of those who can least spare the time, it constitutes an investment which would pay for itself in relatively few years. Obviously, progress in technical education would be the contact point for conversation, and its value would be quickly appreciated by the apprentice.

IN CONSEQUENCE OF SOME extensive repairs and renewals, the Briton Ferry Steelworks are closed down, and it is not expected that they will restart for some time to come.

The A.F.A. in France and Belgium.

The American Foundrymen's Association, together with representatives from the Institute of British Foundrymen, left Paris for Nancy on Tuesday, September 18, and Wednesday morning they visited a salt mine and a glass works in the Nancy district. In the afternoon, there was a Civic Reception at the Hôtel de Ville, by the Mayor, the Prefect of the Department, and two French Army Generals, who displayed to the visitors two flags presented to the town of Nancy by regiments from iPttsburgh and Philadelphia. Addresses were also given by Mons. Masson, the local Vice-President of the A.T.F., and by Mons. Ramas, the President. Thursday was taken up with a motor tour, covering the ground which during the war constituted the sections held by American troops. Nearly all the Friday (September 21) was taken up by the railway journey from Metz to Liege.

The Belgian Visit.

On Saturday morning the visitors were welcomed by the President (Mons. J. Leonard) and officers of the Leige Foundrymens Association, where the party was split into three sections and shown at choice over the works of Cockerill, Conduits d'Eaux, or the Fabrique Nationale d'Armes.

In the afternoon, the Belgian Foundrymen's Association provided private cars to take the visitors to view the Fort Loncin, the last of the Belgian forts to surrender to the Germans. Here they were received by Col. V. Naessens, who was commander in 1914. Mr. G. H. Clamer, on behalf of the American Foundrymen's Association, and Mons. Leonard on behalf of the Belgian Foundrymen's Association, laid wreaths on the graves of the soldiers buried in the cemetery attached to the fort.

At the banquet offered to the guests, held on Saturday evening, about fifty persons were present. Speeches were given by Messrs. Leonard and Remy on behalf of the hosts, to which Mr. Clamer replied for the American Foundrymen's Association, and Mr. H. A. J. Rang for the Institute of British Foundrymen.

Sunday was spent in Brussels, and on Monday the plant of the International Harvester Co., at Croix, near Lille, was inspected. The visitors were received by Mr. S. G. McAllister, the European manager of the concern, and Mr. Cottrell, the works manager. During the afternoon, refreshments were offered, and speeches of thanks were made by Mr. Hoyt, the secretary of the A.F.A. and by Mr. H. A. J. Rang, of Newcastle. After spending Tuesday, September 25, in Paris, the major portion of the party left for Cherbourg, embarking on Wednesday, September 26, on the *Homeric* for New York.

New Catalogues, etc.

Testing Machines.—We have received from Messrs. W. & T. Avery, Limited, of Soho Foundry, Birmingham, a very fine brochure, which deals with all types of testing machines. A section is devoted to the description of foundry testing machines, amongst which is a machine for testing piston rings, a method which has been found useful in other sections of the industry, as formulæ have been worked out so that the results can be readily transformed to those obtained under normal tensile conditions. As, at the moment, the question of test bars for cast-iron is of paramount importance, this issue of the catalogue is very opportune, and foundrymen would do well to procure a copy for their files.

Electrodes for Welding.—The Whitecross Company, Limited, of Warrington, have sent us a neat little booklet, which describes the five types of rods they make using Armco iron as a base. The first type is a plain ingot iron of exceptional purity; the second is similar, but has been coated with a flux; the third is a coated medium-carbon steel; the fourth a coated high-carbon steel, and the fifth a manganese steel. Whilst the first type is claimed to be suitable for cast iron, we suggest to the company that they should place on the market a high-silicon iron, coated with carbon for this purpose, as was described in a leader which we published in our issue of August 23. It is abundantly clear that this firm are working on the best lines, and that they have realised the needs of foundrymen by making a manganese steel electrode; it only remains for them to go a step farther and cater for the cast-iron foundryman.

THE COUNCILS OF THE BRITISH CAST IRON RESEARCH ASSOCIATION AND THE INSTITUTE OF METALS, TAKEN DURING A VISIT TO THE ENGINEERING EXHIBITION AT OLYMPIA.

Forthcoming Events.

OCTOBER 6.

West Yorkshire Metallurgical Society:—Annual general meeting at Huddersfield.

Institute of British Foundrymen (Lancashire Branch):—Presidential address at Manchester. "Pig-iron and its By-products," Paper by J. M. Paul.

OCTOBER 9.

Institute of Metals (North-East Coast Local Section):—Meeting at Newcastle-on-Tyne. Chairman's address, Professor H. Louis, M.A., D.Sc.

OCTOBER 10.

Institution of Welding Engineers:—Corporate meeting in London. Papers on Electric Welding and Gas Welding.

OCTOBER 11.

Institute of Metals (London Section):—Meeting in London. Chairman's address, D. Hanson, D.Sc.

OCTOBER 12.

Institute of Metals (Sheffield Local Section):—Ordinary meeting at Sheffield. "Electric Resistance Furnaces," Paper by A. G. Lobley, M.Sc.

Institute of Metals (Swansea Local Section):—Meeting at Swansea. Presidential address, E. E. Dendy, C.B.E.

OCTOBER 16.

Institute of Metals (Birmingham Local Section):—Meeting at Birmingham. Chairman's address, F. Johnson, D.Sc.

OCTOBER 19.

Institute of Metals (Scottish Section):—Ordinary meeting at Glasgow. "Large Metallic Crystals and some of their Properties," Paper by Professor H. C. H. Carpenter, F.R.S.

Dr. Moldenke on American Foundry Practice.

There was a large attendance at the opening session meeting of the Sheffield Branch of the Institute of British Foundrymen at the Albany Hotel, Sheffield, on August 31.

MR. JOHN SHAW, the Branch-President, occupied the chair, and referred to the loss they had sustained by the death of Mr. W. F. Bagnall, who had been a member of the Association since its commencement, and was a very active member of the local Council.

A resolution of condolence was passed by the members rising.

DR. RICHARD MOLDENKE, the first secretary of the American Foundrymen's Association, and one of the delegates of that body who have been visiting this country prior to attending the Paris Congress, gave an address on "American Foundry Practice." Expressing his pleasure at being present, Dr. Moldenke said he had had so much correspondence with his English friends that he had really got to know them all before he met them. He proposed to give them a rambling talk about American foundry practice, and then his hearers could make their own comparisons. They would probably recognise a good many things that were done in this country. He hoped there would be a discussion afterwards, as he had always found that the discussions were the best part of the evening.

The position as they were facing it in the United States and in the foundry was that their prime requirement was to try to do something to justify the enormous wages they were paying over there. During the war he was called on by the Secretary of Labour at Washington after the wages had gone up by bounds, and he said, "What can we do to justify these so that the men may keep these high wages?" He (Dr. Moldenke) said that education was the only thing to do it. They laid their programme to get the men more information so that they could do their work with a little more brain, get better results, and justify these wages.

Recruiting Labour.

With the high rates of wages that were now being paid in the United States they could understand how it was that their whole export trade had gone smash, and that it was hopeless to trade with the world at the present figures which the people insisted on keeping. Their prime requisite was to get more moulds per man, and also to make a bar of iron go further than ever before. He was very much pleased in going through some of the works in Sheffield, especially at Hadfields, to see so many young men in the shops. In the United States the young men would not go into the foundry. They wanted collar and tie jobs. The ratio used to be that out of 100 boys 9 went to the high school. On an average to-day about 70 went to the high school. They would not go into the shops; they would not work on appliances, and the works had had to put in machinery to take the place of those boys who ought to go in. It was a pity, but that was the situation.

Pittsburgh Castings.

The customer in the United States was after higher quality work. He wanted better castings, stronger castings, and yet wanted them to be able to machine like cheese just the same. The customer also wanted greater accuracy in the dimensions and greater uniformity in the weight of castings, as well as greater freedom from inherent defects and castings with less blemishes upon them. If they ever saw Pittsburgh castings they would be ashamed of them. They were good castings, but they looked very bad because the sand round that region was very poor. So to-day they were at work on the sand problem, trying to get a small-grained sand. Formerly they had to use sand that was almost gravel. The castings were now coming a little better.

Nomenclature of Semi-Steel.

Referring to specifications, Dr. Moldenke said that they had heard, of course, of this so-called semi-steel. It was very fine, but the name was poor. They should do away with it if possible, because the name as used in the United States practically meant the swindling of the customer. It was said, "I have got something better than common iron; it is semi-steel." He made it out of steel scrap, which was cheaper than pig-iron. That was the result, and it was not fair. They had been working to find a better distinctive name for this material. It was being called high-test cast iron, but they hoped someone would suggest another and better name.

The situation the foundryman had to meet was to look for more moulds and better moulds. The thing was to make every single mould count. They wanted to make as many moulds as they could, and make every one right. The next point was the application of metallurgical principles to the moulding process. The foundryman should not be haphazard in his work, but should work the mould and charge his cupolas systematically. After detailing several instances where some slight alteration in the method of charging had resulted in the saving of vast sums of money—in one case $100,000 a year—Dr. Moldenke said they had to study the metallurgy of their processes in addition to the mechanical arrangements in order to get those perfections for which they were looking.

Cost Systems.

Dealing next with a uniform cost system, Dr. Moldenke said that if foundrymen among themselves had a system which would enable them to work on the same lines they would have accomplished a good deal. The first time this question of costing was raised by the American Association was during the time when he was secretary of it, and a number of men were asked to estimate certain costs. One man gave 2½ cents, another 6 cents, and indeed all the figures given were different. This showed the importance of bringing down the element of cost finding to a point where all could work on the same lines, and have the same methods of keeping costs.

Research Work.

Foundrymen should encourage the work of foundry research. In England they were doing some splendid work, and now they were doing the same in the United States. They were working in committees on special lines of their own, and then there was general work by men from all those committees. He remembered during the war getting in contact with a gentleman who told him of a system practised in Germany. An investigation was made into the coal results at works. The results were sent out in tabulated form, and a man could see whether anyone else using the same kind of coal was getting better results than he was. He would then visit the other man's place or would have the information sent to him. In that way he was able to improve his method of using coal, and could save, as was shown in one instance, about one-third of the coal. Such things as that could be worked out by foundrymen. It was being done in this country, and they were doing it to a certain extent in the United States. The electric foundrymen there had got together to carry out research work. They had voted $39,000 a year to elucidate the details of the electric steel foundries, and they found it paid magnificently. Standardisation was an excellent thing to help running in these industries. They had learned by sad experience that it was a good thing to save at the beginning.

Sulphur in Cast-Iron.

Their greatest menace in the foundry business was the effect of sulphur. He had made a good many analyses of the scrap used. About 0.05 per cent. was the average for five years. Afterwards it rose to 0.08 per cent., and during the war they got 0.14 per cent. in their scrap. At the close of the war it was at least 0.18 per cent., and he remembered being in a foundry in Cleveland looking over the analyses day after day, and found as high as 0.21 and 0.26 per cent. of sulphur in the regular work. They had not yet begun to get the castings from the war in their scrap. When they

did come in they would be appalling, because they made castings for the American navy from 90 parts scrap and 10 of pig. They made some in which the sulphur was 0.32, and that had yet to come back.

Critical Factors.

His own life experience in foundry work had shown him that there were three critical points. First the materials. The best materials ought to be got for the purpose. Secondly, they must see that the good materials with which they started were put through the processes properly and rightly so as to bring out good results so far as the processes were concerned. Then the third great cardinal point was the propagating of the moulds to take good material, melted properly and put into the moulds so that it did its work correctly and made good castings. If they obtained those three things right they were on the road to make good castings.

Pig-Iron by Fracture and Analyses.

On the subject of pig-iron, he would like to say that on the previous day in Sheffield he was shown the finest collection of fractures that he had ever seen in pig-iron. But on this point he would point out that in this country they had entirely different problems, and rather more serious than they had in the United States. In this country they had furnaces making foundry iron which made small tonnages, and if they made 80 tons to-day and 80 tons to-morrow that was quite a different thing to the American practice of making 450 tons, 600 tons and 850 tons a day out of one furnace. The British iron was all good, but some of it was better; all the American iron was bad; but some of it was worse.

He believed in educating the workmen to understand analyses and to work by analyses. They could figure out each item of their loss and see how they came out, and they sometimes found that by paying higher prices for scrap, by getting a better grade, they got fuller value in the metal.

Foundry Coke.

On the question of coke, Dr. Moldenke said he did not know much about British coke, but he had always maintained in the United States that if the coke makers would mix their coals so that those very refined coals running to about 8 per cent. in ash were mixed with those running a little higher, giving an average of 10 per cent., it would be very good for the foundryman. They used a good deal of by-product coke. He always liked it, if they would only take the precaution of making it under very high temperatures.

Question of Sand.

On the question of sand, Dr. Moldenke said that if they kept a record of the amount of castings they got from their sand they would sometimes find that the more expensive sand was the cheaper in the end. He divided the processes under three heads. The first was mechanical, which had to do with mechanical engineering; the second was metallurgical; and the third the humane standpoint. He was glad to see that in this country they were perpetuating the art of the moulder, which in the United States was getting lost. At Mr. Ford's big plant in Detroit everything came to the man. He had to get nothing at all. There was a case where everything was pushed to the utmost limit. In one large American motor car works he would undertake to say that they would find that 25 per cent. of his castings were no good, because just some little things were lacking. There was more mechanical skill coming into the foundry in the United States every day. The 28,000 idle men in Sheffield would be a boon to the United States if their legislators were wise enough to allow them to go in.

The metallurgical standpoint was either unknown or not appreciated by the majority of foundry engineers. In the United States they had many chemists who were metallurgists, but taking results and translating them into the works was quite another thing. Many things were done with them, which, if they merely called in a metallurgist to go over the plants they could immediately show some weaknesses which meant indifferent results.

Safety First Considerations.

With regard to the humane standpoint they wanted to increase the number of moulds per man. They could always consider the interest of the workman in this way: the more money a man could get the better he liked it, but he must give results. He (Dr. Moldenke) would give him two or three times as much money if he turned him out two or three times the amount of good work. The next thing was to deal with the question of danger in the foundry. This question of safety was one which their legislators were taking up more and more. In his experience he had found that if they were to get safety in the foundry they had got to make every man think in terms of safety. Whenever a man did anything he should be trained to say to himself, "Is this safe?" The majority of their losses were borne by regular insurance, and at the present time the insurance companies were spreading a lot of information among the foundries as regards safety devices.

Co-operative Research.

The tendency in the United States was to go more and more for top pouring. The whole thing would appear to him to look something like this: the foundryman, beset by all the difficulties he had, was up to the necessity of keeping abreast with the whole line of information. There were few industries which required so much information as the foundry industry did. The next thing was the necessity for studying each problem as it came along—to consider what were the principles involved. When making tests, said Dr. Moldenke, it was a good thing to take their men into their confidence, for it would be found that they could be of great assistance, and he illustrated an instance of this in his own experience. He would like to get the United States Government to spend 10,000 dollars on trying to find out what happened inside the cupola, and to find what they had to do to get good iron. If they melted on too low a bed or in any way got oxygen in they were going to pay for it in lost castings or in castings which were full of "shrinks," and in castings which were full of little fine blow holes, the result of oxidation in the cupola.

The two places in the foundry where they needed to have the best men were on the cupola platform and in the sorting room. Science was a good thing, but they had to apply practice with it. When they applied the two things together they got results. The cupola was the easiest thing to run if they knew how to run it.

Testing Cast Iron.

When a man bought a casting he wanted to know that it was going to do its work. The only way was to break it. That was out of the question, and so the next thing was to test a few pieces. Another way, of course, was to take each casting and put it under pressure. In that way they tested so as to be sure that it was going to be safe. With reference to the test bar, most of them in the United States had come to the conclusion that a test bar, after all, was only the test of the quality of the metal as put into the castings, and the foundryman could still spoil it if he wanted to. But if the quality of the metal was good, and the foundryman knew his business, that was the best the customer could expect. The test bar was used very little in the United States. The customer was satisfied if he knew that the foundryman had a good reputation.

Discussion.

Dr. Longmuir, in opening the discussion, said that Dr. Moldenke had given them a most excellent survey of American foundry practice. He had told them that they ought in all sincerity to admire the foundry cupola. All he could say was that they did admire Dr. Moldenke and the work that he had done so consistently for so many years for the advancement of foundry practice. Dr. Moldenke and he were old friends by correspondence. Dr. Moldenke was one of the first to encourage him, and three of his early Papers were published under the doctor's editorship. The use of a casting was best determined by a test which approximated service conditions as near as possible. He was extremely interested in Dr. Mol-

denke's reference to body. In Sheffield, particularly on the steel-making side, body was thought a good deal of. This was equally so in the foundries of Britain, as Dr. Moldenke would realise before he went back. Body, something that perhaps chemists could not define and metallurgists could only guess at, was recognised in what had been referred to as the low-output blast furnaces. There was a great field for research in a study of something that certain irons, whether cast or wrought, do not possess apart from what is known by their ordinary chemical composition. He wished to express his thanks for the treat that branch of the Institute had had that night. He would especially thank Dr. Moldenke for his very clear definitions of what research should be and of the need for research.

Principles Underlying Quantity Production.

Dr. Hatfield said it was perfectly clear that Dr. Moldenke had made a masterly study of foundry practice, and he could only agree with the bulk of what he had said. As an American, they naturally welcomed him among them, and they were a little relieved to hear that the cost of labour had gone up as much in the United States as it had in this country. That rather equalised things, because it was of world effect. A good deal of the trouble which we thought we alone were experiencing was really being experienced by all the countries, and therefore if the various populations really put their backs into the work he had no hesitation in saying that probably a better world would arise in a few years time than existed before the war. The most important thing that Dr. Moldenke said was said inadvertently, when he spoke of orders for 40,000 and 100,000 castings. That, of course, was the key to the dissimilarity in the methods of production in America and in this country. America was a newer country, and they had learned the value of the centralisation of capital and industry earlier than was done over in this country. He also thought that there were not so many constructive minds in America as here, and by here he did not mean in this country but in European countries. The type of mind such as Dr. Moldenke and Mr. Ford possessed could be found in this country, not in such a high standard of excellence but in greater numbers. That meant that there were more attempts at development over on this side. This country had many small firms; in the United States they had fewer but larger firms, and of course larger firms could give larger orders to the foundry industry. What they wanted to see on this side was more of that system in operation. Personally he thought that the tendency to higher education in America was a very good feature, and he believed it could be said that the same tendency was in operation here. It had been very definitely in operation in Germany, and in the Scandinavian countries, and in other countries, it had been extremely well developed from the industrial point of view and likely to give the Anglo-Saxons a very good run for their money in the next few years. With reference to test bars, there was only one possible ruling, and that was that the test bar was entitled to give to the consumer, to the engineer who was using the casting, a definite idea of the properties of his casting. The engineer was not interested in the fact that the iron in the casting was good iron. He wanted to know what his casting was like, and therefore it was necessary that the test bar should represent the casting. That was the attitude of mind of the English engineer, and if they simply submitted a test piece of the iron they could not expect the engineer to have a sufficient knowledge of the details of the foundry industry to be able to weigh up the various influences at work which in the casting might produce a different result from that which was found in the test piece. As regarded the balance of coke and pig-iron he agreed with Dr. Moldenke, and he might be interested to know that in Sheffield foundries they worked on 1.7 cwts. of coke per ton of iron, which, of course, was quite in line with the best American practice. He agreed that the term "semi-steel" should be discarded. A uniform costing system, of course, was really necessary in any industry where there was competition, because otherwise there was very foolish competition. He thought all industries should at any rate exchange ideas sufficiently to have a common basis of calculation. He personally heartily endorsed the truly American sentiment which Dr. Moldenke had put before them, that payment should be by results. In these days when there was so much politics mixed up with industrialism, there were false ideas abroad. It was necessary that if they were to eat they must work. That was a fundamental. He did not know that among Sheffield manufacturers there was a strong desire that payments should be limited. If a worker would only do good work and put the right kind of energy into his work he might very largely indeed enhance the earnings which he could take home. There were difficulties in the way of translating an idea of that kind into practice, but by the friendly and liberal exchange of thought which was going on between the employers on the one side and labour on the other, there was every appearance that equitable conditions would be arrived at compatible for both the worker and the employer, and the net result would be that production would attain a standard which it had not attained before. Then, just as in Pittsburg, the British workmen would come to their work in motor cars. On the question of testing Dr. Hatfield said that the thing to do, was to cast the test bar on to the casting. The reason for that was that if they cast their test bar on to the casting the speed of cooling of the test bar was determined by the size of the casting, and it was the speed of the cooling which largely determined the strength of the test bar. That particularly applied to cast iron. If the designer was to satisfy the man who was ultimately to use the device he had to show what the strength of the material in his casting was. He had no other way of getting it other than by cutting a test piece from the casting or having a test piece of dimensions similar to the casting cast on. This idea of casting test-bars separately did not appeal to him at all. There was such a thing as confidence between the producer and the consumer, and what they had to achieve and maintain was that confidence. If the principle which he had been suggesting was carried out they would thereby gain the confidence of the consumers who knew something about the business.

Mr. Upton said that if the works managers, foremen, and others in control of foundries in this country would only look after their men and see that a moulder was a moulder and not a labourer, they would get results equal to America or any other country in the world. He did not think that there was a finer man than the British working man to be found anywhere. If he was properly looked after those results would be forthcoming. A large number of cupolas were often in difficulties. The cupola was the basic of all foundry practice, if that went wrong it did not matter what they did elsewhere.

Mr. Ambrose Firth proposed, and Commander Jackson seconded, a resolution of thanks to Dr. Moldenke for his address. This was carried, and the Doctor briefly replied.

LANCASHIRE BRANCH DISCUSSION.

At a meeting held on September 1, at which Mr. R. A. Miles presided, Dr. Moldenke repeated his lecture, which gave rise to the following discussion:—

Mr. S. G. Smith said he did not think there was a foundryman present who had not read, in some shape or another, part of what Dr. Moldenke had written, and it was a great privilege to have the opportunity of listening to this address.

Sulphur Reduction by Soda Ash.

One very important point was the increased proportion of sulphur in scrap iron. In England it was gradually rising towards the end of the war and just about a year after the Armistice it reached its highest point, and some of them were puzzled how to remove that sulphur. Dr. Moldenke had mentioned a method which was new to most of them —the use of soda cakes—and he would like more information to be given regarding that. If a soda cake was put on the top of the iron how was that going to draw the sulphur from the bottom of

the ladle? Was there some particular way of applying?

Dr. Moldenke had touched upon an immense number of subjects, some of which, each by itself, would have been sufficient for one afternoon's discussion. He himself had had much experience with the question of shrinkage. Those who had read his articles dealing with the problem of the foundry, which had appeared in the Foundry Trade Journal during the last two years, would see what a variety of matters came into this question of shrinkage. Dr. Moldenke truly said that every important casting had its problem, and what applied to one might not apply to another.

He would not venture at that moment to deal with the question of the test bars, but his view was that a test bar should represent the metal not the casting. He firmly believed that a test-bar could never represent a casting, no matter what its thickness was.

Dr. Moldenke said in America the percentage of sulphur rose to the highest point after the war, when the foundries were also suffering from the effect of bad iron and inferior coke. In those respects the English foundries were better off than the Americans, who had enormous furnaces producing enormous tonnages. When the soda cake was thrown on the molten iron there was an immediate action throughout. That was proved by the fact that whether a sample was taken from the top iron, the middle iron, or the bottom iron, it was found to be identical in composition.

Mr. Smith: Is it the ordinary raw material?

Dr. Moldenke: Soda ash, the cheapest.

Mr. H. Sherburn said this was a very proud moment for the members of the Lancashire Branch. Many of them had read the contributions of Dr. Moldenke to the technical journals for many years, and also that wonderful book of his. Contact having been established in that way, they had now the privilege of amplifying it by seeing him and listening to his words.

He thought it was a difficulty with all of them that somehow the problems they were up against often led them to hold pet theories about different experiences, to cherish certain prejudices, and it was very good to have the corrective of Dr. Moldenke's contribution to their knowledge and practice.

The question of sulphur was a very serious one, although there were people who said that sulphur was actually a good thing within limits and under certain conditions. One of the difficulties was that in the first melting in the cupola some foundrymen used a very small amount of flux. What did Dr. Moldenke consider a good average amount of limestone to use, say for a ton of iron? His own practice was rather unorthodox in that he used a considerably greater amount of limestone than any of the friends with whom he had discussed this question. It seemed to him that if the sulphur was kept as low as possible in the first melting, the problem would not be so acute as it otherwise tended to become later on.

He understood Dr. Moldenke to say that he would not use shot iron in the cupola. In foundries which produced very light castings, where there was a lot of hand-ladle work, a considerable amount of shot would accumulate, and this presented a problem. He wondered whether Dr. Moldenke could suggest a better way of dealing with it than simply putting it into the cupola.

Height of Coke Bed.

Another question he wished to ask had reference to the height of the bed charge of the cupola. If Dr. Moldenke would give them some idea what the height in inches should be, say above the top of the tuyeres, that would be very helpful. Personally he always commenced melting operations with the coke bed up to a certain level. Quite apart from any question of the weight of the coke charged, the bed must be maintained at a certain spot. He had tried lowering the bed, and certainly the metal would come down quicker in the first instance, but at the end of a period there was a tendency for trouble to occur with the tuyeres. The question then always arose whether it was wiser to increase the height of the bed in the first place or to increase the weight of the subsequent coke charges. His own observations led him to the conclusion that it was better to keep the bed well up at the outset, but he would appreciate Dr. Moldenke's views on the matter.

Dr. Moldenke said the height of the bed was not governed by the weight, but it was necessary to consume the proper amount of air in order to get the necessary reaction, and that would be influenced by the height of the bed. The volume of air put into the cupola must never be slackened, as that would affect the position of the bed, but if it became necessary, for instance if the cupola was found to be furnishing too much iron, it could be shut off for a time and resumed afterwards. One could shut off or run the blast as he pleased provided the volume when running was not changed.

Dealing with the question of fluxes, Dr. Moldenke said with very clean metal only 1 per cent. of limestone would be needed. For sprues that had not been cleaned it was necessary to take about 3 per cent.; for very dirty scrap and iron one might have to go as high as 4 per cent. When running continuously, 4 per cent. was necessary in any case, in order that the slag might run below the tuyeres quickly.

Tuyere Ratios.

Mr. Key asked what Dr. Moldenke would consider the correct tuyere ratio for a 40-in. cupola assuming that the blower was of sufficient capacity to deliver the necessary amount of air. Also what blast pressure in inches or ounces would he reckon on for such a cupola?

Dr. Moldenke: Forty inches—that would be about 5½-tons capacity per hour.

Mr. Key: We have melted 7 tons per hour, but we melt 5 tons per hour because with the smaller quantity we get an improved iron.

Dr. Moldenke said the proportion ranged from 1 in 5 for small cupolas to 1 in 10 for large cupolas. The situation was regulated by the volume of the blast. If the proportion of the blast to the size of the cupola was correct, the blast pressure would run from about 7 ozs. up to 16 ozs., depending upon the resistance afforded by the charges to the passage of the air. If they were very slaggy they would naturally resist more.

Mr. Key: Assuming you have got the correct tuyere ratio, what would you recommend as the permanent pressure?

Dr. Moldenke replied that really one could hardly say there was a permanent pressure, because it varied. It would run low at the beginning, and at the end it would run high. The volume gauge was more important than the pressure gauge, because in order to get the proper combustion it was necessary to have a fixed volume of air blown into the cupola.

Bottom Shrinkage.

Mr. Markland asked whether Dr. Moldenke had come across a case where the skrinkage, or the drawing as it was called here, of the iron was at the bottom instead of at the top. In the case of a 3-16ths section with a rib on the top of it he found it was quite hollow underneath. It came right from the surface. He had been much troubled with that, and he thought the reason was that the iron was too soft, but he would like to have the benefit of Dr. Moldenke's experience.

Dr. Moldenke said he was of the same opinion, and he could give one instance of a very long table which had spots. The reason was that they used iron that was too good for the purpose. It would not happen if a lot of scrap was put in.

Mr. J. Hogg said Dr. Moldenke spoke like a Britisher on what was described as the "humane" side, which included the elimination of hand labour and accident prevention. He had been led to believe that America only cared for production, but apparently that was a misapprehension.

Dr. Moldenke's observations about the cupola agreed with the views he had expressed many times. In his opinion, especially where the diameter was small, a simple cupola with a straight shell was the best form, provided one kept the correct height above the tuyeres. If the foundryman followed the directions for determining the height of the bed, there was no need for the elaborate forms of tuyeres which were sometimes seen. As regards the height of the tuyeres from the bottom of the cupola, in his own practice he had raised that to 6 in., but it was done

simply in order to hold more metal in the bottom of the cupola. Unless that object was in view it was really a waste of coke to place the tuyeres too high.

Dr. Moldenke said it was important to mix the charges carefully, so that all the ingredients—the pig-iron and the scrap—would mix together properly in every part, so that when melted they obtained iron of the same character throughout.

Vote of Thanks.

Mr. Smith, in proposing a vote of thanks to Dr. Moldenke, said there seemed to be a similarity between him and Mr. Thomas D. West, but there was this difference that the latter was a practical foreman and foundry manager, whereas Dr. Moldenke was a highly skilled technical and scientific man. If Thomas D. West were now living he would be near the same age as Dr. Moldenke. At the "Welcome" dinner given by the National Ironfounding Employers' Federation to the American visitors on the previous evening he (Mr. Smith) had the pleasure of sitting near Mr. R. West, the son of Thomas D. West, who, on this his first visit to England, had been able to procure a copy of the birth certificate of his father, who was born in Manchester. So although he was a great American, he was primarily a Britisher. Indeed, American foundry practice sprang more or less from English foundry practice. Some thirty or forty years ago one could hardly go into a foundry in the United States and not find a Britisher as foreman there.

He wished they could have Dr. Moldenke with them once a year. Amongst themselves they had thoroughly discussed almost threadbare some of the matters which had been touched upon in the address, and they fully appreciated the importance of Dr. Moldenke's remarks. In the matter of moulding sands he quite agreed with what was said about the size of the grains. If they were all large it was good for heavy work, if they were all small it was good for light work, but a mixture of the two was bad for both large and small castings.

Mr. W. H. Sherburn, in seconding the vote of thanks, said it was not a stranger from a foreign land whom they were welcoming, but a man whom many a foundryman knew better than he did his next door neighbour. Looking through some old foundry technical literature of 25 to 27 years ago, he came across one of Dr. Moldenke's letters, which he read with special interest, because it stated what the foundryman would do in the future, and experience had shown that Dr. Moldenke was right. Prophecy helped to bring about the things predicted when it inspired people with confidence to attempt them. Not every prophet lived to see his prophecies verified, and Dr. Moldenke was fortunate in that respect, nor was he without honour in his own country. For more than a quarter of a century, he had been an inspiration to British foundrymen, and had set them reading and thinking. He had let light into the dark corners of the industry. Twenty-five years ago there were many dark corners, and some people tried to keep them dark; if they learned anything, they wanted to keep it to themselves. Dr. Moldenke had done more than any other man to dispel that view, and they wished him success in his future efforts in that direction.

The vote of thanks was carried with acclamation. In replying, Dr. Moldenke remarked that Thomas D. West was one of his best friends, and they worked together. He was an ideal worker; no man could make experiments better, and they co-operated at a time when they had to grope in the dark and work things out for themselves.

The seventh annual whist drive in aid of the funds of the Royal Metal Trades' Pension and Benevolent Society will take place (under the direction of the auxiliary committee) at the Finsbury Town Hall, Rosebery Avenue, E.C.1, on Saturday, November 3. The chairman and M.C. will be Mr. Arthur E. Robey, of Cakebread, Robey & Company, Limited, Caroba Works, Wood Green, N.22. Tickets of admission, 5s. each (including refreshments), may be obtained from the chairman, members of the auxiliary committee, the stewards, or the secretary, at the offices of the Society, 195, Upper Thames Street, E.C.4.

Cohesion and Molecular Forces.

On Thursday, September 13, Section A (Mathematical and Physical Science), Section B (Chemistry), and Section G (Engineering) of the British Association, at the Annual Meeting at Liverpool, met for a general discussion on "Cohesion and Molecular Forces."

Sir William Bragg, F.R.S., who opened the discussion, said that the word cohesion was rather getting away from its proper uses. At one time it only applied to forces between atoms and molecules productive of causes of capillarity and surface tension, but the more the subject had been discussed the more it had been found that the forces of cohesion were not peculiar to this one section of physics and chemistry, but were common to all forces. In the early days we had been compelled to deal with these forces of cohesion in the aggregate. Now it was essential to get down and know the nature and effect of cohesion as between atoms and molecules themselves. That had been the whole trend of modern practice during recent years, and it was only by studying the particular atoms themselves that we could get to know anything about these forces. Recent investigation went to show that each atom did not act as a whole, but acted at a number of different points on its surface, and that the forces which were exerted had an extremely small range. Therefore we must think of molecule acting upon molecule and building up just in the same way as a girder structure was built up, and he preferred that view to the older view of general attraction between molecules. His point was that a molecule must be considered as a comparatively complex body with various points to which others were attached, and it was only by thinking in that way that a movement in the direction of true investigation could be made to find out what were the real forces acting between the individual atoms of the molecule. The trouble in the past had been that we had thought too much in the direction of aggregates.

Dr. W. Rosenhain, F.R.S., said that metallurgists had an advantage in this matter in that they were able to deal with the simplest kinds of solid bodies, which were non-atomic in constitution. The results obtained with crystal analysis had enabled consideration to be given to a single atom, and this had also enabled us to go a step farther and realise the effects which would result in a space lattice consisting of individual atoms of a metal when certain of the atoms were replaced by similar or stranger atoms. This was the more important in the case of metals because cohesion phenomena were much more strongly marked in metals than organic salts or several of the inorganic salts. The closeness with which atoms approached each other had an enormous influence upon the behaviour of metals in subsequent working, and therefore it was essential to know the conditions which permitted of the atoms bonding themselves together more closely or less closely.

He put forward the suggestion that the forces applied at the crystal boundary were greater than in the crystal itself. At the same time, the problem of diffusion in the crystal was not a simple nor an easy one, because it was bound up with the problem of ductility. In the crystal boundary the arrangement of the atoms was more dense than in the crystals themselves, and therefore it was not surprising that the diffusion of gases and solids in the case of metals took place along the crystal boundaries. His main point was that a detailed knowledge of metals and alloys, together with the wonderful light which had been thrown upon the structure of the crystal by X-ray analysis, was enabling us to form a clearer picture of the internal mechanism than had hitherto been dreamed of.

Dr. A. A. Griffith said that the branch of engineering which was most intimately concerned with the phenomena of cohesion and inter-molecular force, was the science of elasticity and strength of materials. Whilst the majority of structural metals were ductile and the primary failure did not involve atomic separation at all but was a failure in shear. Nevertheless, in the case of certain materials, such as glass, stone and hard steel, which exhibited brittle fractures running perpendicular to the direction of greatest tensile stress, the shearing type of failure did not occur at all. A large discrepancy apparently existed, inasmuch as the tensile strengths were only a small fraction of the molecular tenacity. Thus, in the case of a dead-hard steel, the applied tensile stress necessary for fracture was only about 71 tons per sq. in., while the cohesive forces to be overcome in order that fracture might occur corresponded with a tensile stress of the order of 2,100 tons per sq. in.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Testing Cast Iron.

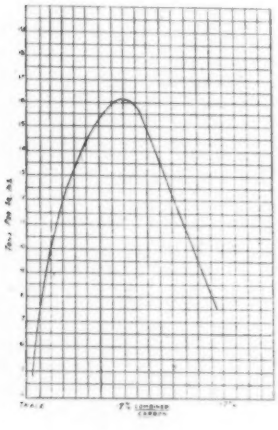
To the Editor of The Foundry Trade Journal.

Sir,—In order to make my position quite clear as to the subject of an International Arbitration Bar, I have pleasure in annexing a precis of the views I expressed when discussing Dr. Moldenke's excellent Paper presented to the Paris Conference.

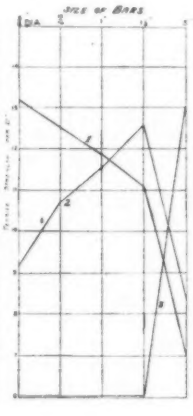
I pointed out that three propositions had been submitted in the Paper, viz.: (1) The Fremont and Portevin methods of testing; (2) the American specification for grey iron; and (3) the tentative specification prepared by the I.B.F.

Taking them in order, the Fremont may be a suitable test for C.I., but as no progress has been made in its use in even any French specification since its Author first brought it forward fourteen years ago in Paris, it cannot be considered seriously for an international specification at the present time.

Two fundamental differences appear in a comparison between the American and British specifications. The former claim, and personally, I think rightly so, that the test bar represents the quality of the metal used, and not of necessity the strength of the casting. They therefore cast the bars separate under stabilised conditions. The British (influenced by the fact that engineers in their country have called for the test bar to be cast on for many years) still adopt the principle that



Graph I.



Graph II.

the test bar shall be cast under the same conditions as the casting it represents. It must be remembered that physical tests for cast iron have been included in the specifications for our great export and home trade for a hundred years, based to a great extent on actual tests on sections carried out by Sir William Fairbairn at that time. With our increased knowledge of "mass action" and cooling effects on C.I., it is feasible that a compromise may be arrived at on this first point, but so far as the British are concerned, it must carry the consent of our engineers with it, unless the use of the specification is to be a dead letter.

When it comes to the second point, I am afraid the International Committee will not carry the British Committee with them in the use of one size bar with varying loads for each thickness of casting. The British Committee maintain that is fundamentally wrong, as I think the diagrams will show. Take No. 1: Professor Turner, Cook and I found that the strongest iron was obtained with a C.C. of from 0.6 per cent. to 0.8 per cent., according to the amounts of the other elements present. The graph shows that with a trace of C.C. one obtains about 5 tons per sq. in. tensile. This gradually increases with the increase of C.C. up to about 0.7 per cent. C.C., when in this case a tensile strength of 16 tons was obtained. The strength then falls away with each increase of C.C. until with 1.2 per cent. C.C. there is a badly mottled bar with a test result of only 7½ tons per sq. in.

With the above facts in mind, turn to Graph II. In these experiments five different sizes of bars were used, viz., ⅜ in., ⅝ in., 1 in., 1½ in., and 3 in. dia. Several sets were made; each set was cast together out of one ladle. The first were made from a mixture cast into some small cylinders ⅜ in. thick, and suitable for strong, thin castings. It will be noticed that the ⅜ in. dia. bar gave a breaking load of over 13 tons per sq. in. A gradual fall is registered until with the 3 in. dia. bar only 7 tons per sq. in. is obtained. This is the result one would expect from this type of metal. The second mixture used was suitable, and was used for steam cylinders about 1½ in. thick. It contained about 1.2 per cent. Si and about 0.1 per cent S. This iron was too hard for the ⅜ in. dia. bar, and only a little over 9 tons per sq. in. is obtained. There is a gradual rise to the 1½ in. dia. bar with a breaking load of 12½ tons per sq. in. The breaking load again falls to 8½ tons per sq. in. for the 3 in dia. test bar. The last mixture, No. 3, was used to cast a series of hydraulic cylinders 4 in. thick, which were bored out and tested to 2,240 lbs. per sq. in. All the bars were white except the 3 in., which was quite grey, and gave the Admiralty over 13 tons per sq. in. tensile. The C.C. in the small bars reached 3 per cent. out of 3.2 T.C. The C.C. was 0.9 per cent. in the large bar showing the great effect of mass action and cooling effect on the same metal. It was not possible to tool any of the smaller bars, so no tensile tests were possible.—Yours, etc.,

J. Shaw.

Montgomery Road, Sheffield.

Industry and Pension Fund.

In all branches of industry the value of funds which make provision for the worker in old age is being increasingly recognised, and the superannuation movement is steadily growing. Such funds tend to harmony between employer and employed, and foster a spirit of co-operation and goodwill. From the employee's point of view they remove anxiety as to maintenance when working days are past, and, by assisting retirement at a reasonable age, hasten the promotion of younger men, which, in the past, has too often been lacking. From a national standpoint, they are to be encouraged, as they lessen the burden of State Old Age Pensions and of Poor Law relief.

"The Association of Superannuation and Pension Funds" has developed from the Conference of Superannuation Funds, which was established by representatives of leading funds in 1917. The primary object of the Conference was to obtain exemption from Income Tax of the income derived from investments of superannuation funds, and this was eventually obtained under the provisions of the Finance Act, 1921.

The Conference proved useful in other ways, and it was resolved to form a permanent association, with defined objects. Briefly, these are, the furtherance of the interests of superannuation and similar funds and the general development of the movement. The Association is managed by a Council representative of industrial, transport and other funds; it holds periodical meetings and acts in an advisory capacity to its members. It has considerable information relating to a variety of funds, and expert assistance in the formation of funds is available, obviating in many cases the need for expensive professional advice.

The association of a large number of funds gives strength to the movement generally, while the members have the advantage of a central body which can advise and deal with questions as they arise.

Superannuation, pension and similar funds are eligible for membership, and associate membership is open to companies, firms, bodies and individuals who may be interested.

The Secretary of the Association is Mr. R. P. Summers, Electric Railway House, Broadway, Westminster, S.W.1, who will be pleased to answer inquiries.

Effects of Rate of Cooling on the Density and Composition of Metals and Alloys.*

By R. C. Reader, Ph.D., M.Sc.

The effect of the rate of cooling of alloys is of great importance and is now engaging the serious attention of many metallurgists. It is recognised that the rate at which an alloy cools may be responsible for its resulting properties, both physical and mechanical. In a recent Paper presented by the author† it was shown that the useful mechanical properties of 10 per cent. Al.-Cu. alloys are adversely affected by a slow rate of cooling. In the present note numerical values are recorded showing the effect upon the density and composition throughout the mass of metals and alloys due to different rates of solidification.

Effect of Rate of Cooling on Density.

On examining the densities of a binary system of alloys for both sand- and chill-cast specimens it will be noticed that where a long solidifying range exists there is a marked difference between the densities of the sand-cast and chill-cast specimens. In this case the chill-cast specimens, which solidify at the greatest rate, have the higher densities. Whenever there is only a short solidifying range for the alloys, or where the solidus and liquidus curves meet, the densities of sand-cast and chill-cast specimens coincide.

The method of density determination was as described in the author's previous paper.

Effect of Rate of Solidification on the Density of Pure Metals.

In the case of pure metals, no appreciable variations in density can be found for different rates of solidification. This is illustrated by the values in Table I. for various pure metals.

Table I.

Diameter of Bars in inches.	Tin.	Lead.	Zinc.	Aluminium.
¼	7.282	11.331	7.114	2.688
½	7.280	11.321	7.115	2.678
1	7.287	11.323	7.129	2.680
1¼	7.292	11.336	7.130	2.680

The four bars of each series were cast at the same time, from a central runner, and so were originally at the same temperature. By casting the bars in different sizes varying rates of solidification are obtained, the thin bars cooling more rapidly.

The differences in density between the four bars of each series are so small as to be regarded as being within the limit of experimental error. It may therefore be concluded that the density of pure metals, if poured within a suitable range of temperature is not affected by rate of solidification.

Effect of Rate of Solidification on the Density of Alloys.

Alloys of 10 per cent. aluminium-copper, 40 per cent. zinc-copper, and 10 per cent. tin-copper were selected as being suitable for the purpose in view.

On account of the difficulty experienced in obtaining sound sand castings, the method used was to cast a bar in a chill mould, and afterwards to turn the bar down in a lathe, removing ⅛-in. thickness at a time; a density determination of the residue of the bar was made after each turning, and the density of the removed layer was found by calculation. The outer portions of a chill-cast bar will solidify at the greatest rate, and the central portion at a much slower speed, and if the rate of solidification affects the density then variations should be encountered between the outside and central portions of the bar.

Density values (grams per c.c.) of sections of the alloys are given in Table II., together with calculated density values for the concentric layers removed from the tin-copper specimen.

* Extract of a Paper presented to the Manchester meeting of the Institute of Metals.

† R. C. Reader, "Journal of the Institute of Metals," 1923, 29, 305.

Table II.

Diameter in inches.	10 per cent. Aluminium-Copper.	40 per cent. Zn-Cu.	10 per cent. Tin-Copper.	
			Whole Specimen	Concentric Layer.
1¼	—	8.073	8.770	—
1⅛	—	8.075	8.760	8.905
1	7.504	8.080	8.732	8.883
⅞	7.503	8.087	8.690	8.859
¾	7.504	8.082	8.645	8.827
⅝	7.600	8.082	8.567	8.818
½	7.498	8.385	8.486	8.717
⅜	7. 95	8.394	8.415	8.588
¼	7.492	8.386	8.344	8.472
⅛	7.487	—	8.307	8.352

It will be seen from the above figures that the densities of the 10 per cent. aluminium-copper and of the 40 per cent. zinc-copper alloys, which solidify at a constant temperature, are only slightly affected by rate of cooling, while the density of the 10 per cent. tin-copper alloy, which solidifies over a range of temperature, is varied considerably, the slower the rate of solidification the lower being the density.

The calculated values for the densities of the concentric layers removed are interesting. The first five layers removed show a small and gradual decrease in density compared with the larger decreases which take place between the remaining layers. These calculated values, therefore, tend to show the existence of central unsoundness, or rather porosity, as no visible signs of unsoundness were encountered during turning. A similar phenomenon has been found to occur in the case of the "Y" alloy.

Effect of Rate of Cooling on Composition throughout the Mass.

It would be anticipated from a study of an equilibrium diagram that in a quickly cooled alloy the outer surface would be richer in the component of the higher melting point. In many alloys, however, this condition does not exist, but what is known as "inverse segregation," when the outside of the casting is richer in the component of the lower melting point.

Consider first the case of alloys which solidify over a range of temperature, for which the 10 per cent. tin-copper alloy may be taken as a suitable example. When prepared in chill (1¼ in. dia.) and the outer and central portions analysed the following results were obtained:—

Outside layer (1¼ to 1⅛ in. diameter) 10.53 per cent. tin.
Centre (less than ¼ in. diameter) .. 9.47 „ „

The analysis of a sand-cast bar of a similar size and cast from the same pot of metal were 10.46 and 10.27 per cent. tin respectively.

The figures show the chill-cast bar to be inversely segregated and the sand-cast bar to be practically homogeneous.

Inverse segregation was not encountered in the two selected alloys investigated, which solidify at a practically constant temperature, as shown by the following figures for chill-cast specimens:—

	10 per cent. Al.-Cu.	40 per cent. Zn.-Cu.
Outside layer ..	10.84 per cent. Al.	60.30 per cent. Cu.
Centre ..	10.70 „	60.43 „

Variations in casting temperature influence the amount of inverse segregation. For example, when two separate bars of 10 per cent. Sn-Cu alloy were cast in chill, one cast at 1,230 deg. C. and the other at 1,050 deg. C., the bar cast at the higher temperature was inversely segregated to the extent of 0.93 per cent. of Sn and the other 0.64 per cent.

The size of the casting also has an appreciable effect on inverse segregation, since it was found that a bar of 10 per cent. Sn-Cu, of a diameter of 1¼ in., was inversely segregated to the extent of 1.1 per cent., while a bar of 1 in. dia. showed a Sn enrichment on the outside of only 0.5 per cent.

It has been shown that chill castings only are subject to inverse segregation, the sand castings being practically homogeneous throughout. On the other hand, it has been shown that higher

casting temperatures and larger castings, both of which give a slower rate of cooling, give rise to increased inverse segregation. It is therefore anticipated that there must be a critical rate of solidification which will produce maximum inverse segregation.

Annealing at high temperatures for long periods does not readily remove inverse segregation once it has occurred, as a chill-cast bar, of 1 in. dia., after an annealing at 750 deg. C. for ten hours, was still inversely segregated to the extent of 0.41 per cent. Sn.

Cause of Inverse Segregation.

Several explanations have been offered in the past to account for this phenomenon. A most probable solution, however, can be obtained from the work of Gulliver.* Briefly the results of his work show that the effect of rapid solidification is to move the phase fields of the equilibrium diagram. In other words, he showed that a tin-copper alloy containing 7 per cent. of tin, which on slow cooling should consist of a solid solution, on rapid cooling can consist of 83 per cent. of α, 14 per cent. of β, and 2.9 per cent. of γ. Hence in a chill casting we get more tin-rich constituent thrown out than in a sand casting. Now, during solidification, stresses are set up due to the contraction of the already solidified crust of metal, and this contraction compresses the inner still molten metal, which will be compelled to ooze through the already formed Dendrites, causing the enrichment on the outside in the lower melting point constituent. The phenomenon of inverse segregation is considered to be a modified form of tin sweat, such as occurs in phosphor-bronzes.†

Practical Applications.

Specimens to be used for the purpose of comparative density determination should always be prepared in a similar manner—that is, they should be cast with the same superheat into moulds of similar size, the actual specimens themselves removed from the corresponding place in each bar, and they should be turned down to the same diameter, as a variation in one of these conditions will cause a slight variation in the density.

In drilling a specimen in order to obtain pieces for analysis care must be taken to drill completely through the specimen (whenever possible), in order to obtain a representative sample.

The author wishes to extend his thanks to Professor T. Turner, M.Sc., A.R.S.M., in whose laboratories the work was carried out, for the interest he displayed in the various experiments and for the advice he tendered.

RICHARD SIMON & SONS, LIMITED, the Rawlings Manufacturing Company, Limited, the Graesser-Monsanto Chemical Works, Limited, John Elwell, Limited, Bower Electric, Limited, the Yorkshire Railway Wagon Company, Limited, and Pegler Bros. & Company (Doncaster), Limited, have been elected members of the Federation of British Industries.

The French Seizure of German Steel.—As previously noted, the French Government has appointed an inter-Ministerial Committee to consider questions relating to the disposal of iron and steel products seized in the Ruhr or "to be seized" there. As compared with the quantities originally reported to be at stake, it is now stated that the scrap alone amounts to 300,000 tons, while the semi-finished products are estimated at 100,000 tons and the finished are declared to vary between 600,000 and 800,000 tons. The advice of various commercial organisations as to the best method of disposing of these products having been sought by the Minister of Public Works, it is understood that the Comité des Forges has undertaken to constitute a commercial organisation for handling the 300,000 tons of scrap, and for effecting similar transactions in the other material. Consignments from the Ruhr are apparently to be subject to the French import duties, either under the general tariff or the minimum tariff, but it will be necessary for this point to be definitely settled before it will be possible for any organisations to deal with the products under the conditions to be settled by the Minister of Public Works.

* "Metallic Alloys," by G. H. Gulliver (Griffin), 1921, p. 410.
† Rowe, "The Foundry Trade Journal," Vol. 27, p. 354.

Changes in Italian Import Duties.

Owing to the fact that Italy has little coal and very small reserves of iron ore, the industry has always received some assistance and protection from foreign competition. Although iron and steel exportation to any large degree is prevented by the lack of raw materials, many champions of the industry claim that Italy should satisfy the demands of the home market since much of the needs of the country would cost considerably more if bought abroad. Italy is now equipped with nine coke blast furnaces and 113 electric steel furnaces, of large and medium capacity, and 60 small ones.

The import tariff has lately been modified for some commodities, including iron and steel products, by the Italian Chamber of Deputies. Many of the rates that have been modified cover commodities for which special conventional duties already exist with France, Switzerland and Austria. A special list of new conventional duties on a number of articles has been drawn up, which will apply to nations receiving the most-favoured nation treatment. Reduction of the tariff on pig-iron should facilitate the running of the steel plants, now that cast-iron scrap is free from duty.

With the Royal Decree of July 11 last the following changes in the import duties were arranged per 100 kilos (220 lb.):—Pig-iron which paid in 1911 Lire gold 4.375 (3s. 6d.) is now charged Lire gold 3.12 (2s. 6d.) under the general tariff, and Lire gold 2.81 (2s. 3d.) under the preferential tariff; spiegeleisen, which paid Lire gold 6.125 (nearly 5s.) in 1911, is now charged at Lire gold 4.375 (3s. 6d.) under the general tariff, and Lire gold 4.112 (3s. 3½d.) under the preferential tariff; pig-iron, that paid Lire gold 5.40 (4s. 3d.) in 1911, is now charged Lire gold 4.80 (3s. 10d.) under the general tariff, and Lire gold 4.20 (3s. 4½d.) under the preferential tariff. Steel ingots, which paid Lire gold 5.40 (4s. 3d.) to 12 (9s. 7d.), now pays a general tariff of Lire gold 4.50 (3s. 7½d.) to 9 (7s. 3d.). Steel blooms, that paid an import duty of Lire gold 10.50 (8s. 5d.), now pay under the general tariff Lire gold 7.80 (6s. 3d.), and under the preferential tariff Lire gold 6 (4s. 9½d.). Steel bars and rods, that paid an import duty from Lire 12.60 (10s. 1d.) to 27 (21s. 7d.), now pay under the general tariff from Lire gold 11.60 (9s. 4d.) to 23 (18s. 5d.); and under the preferential tariff from Lire gold 10.15 (8s. 1½d.) to 20.25 (16s. 3d.).

BIDS WILL SHORTLY be invited for the steel work on a railway bridge to be constructed over the Mossoro River, State of Rio Grande do Norts, Brazil. The cost must not exceed 1,000 contos (about £200,000). A contract has been entered into between the Government of Panama and Senor Don Enrique L. Huatardo for the construction of a new railway 30 miles in length, more or less, from Caledonia Bay, on the Atlantic Coast, to a point between the Ucurganti and Sanson rivers in the valley of Chucunaque, near the borders of Columbia. The line will be of narrow gauge.

Important Steel Development in Australia.—Mr. Charles Hoskins, director of Hoskins, Limited, the Lithgow (N.S.W.) firm of steel-makers, has informed the Public Works Committee of the New South Wales Parliament, which is conducting an inquiry as regards a proposed railway from Moss Vale to Port Kembla, that if the line were constructed his Company would spend £2,000,000 in the erection of iron and steel works at Port Kembla, where 380 acres of land had been secured for the purpose. This would not mean the closing down of the Lithgow works. Mr. Hoskins explained that the Lithgow works were practically unable to compete for inter-state trade, owing to the freight charges from Lithgow to Sydney. If the proposed line were built, his Company would draw iron ores and limestone from the southern district, and would effect a saving of 5s. per ton on ores, in comparison with the freight via Sydney, which was equal to 12s. 6d. per ton on the finished article. He considered that if iron and steel works were established at Port Kembla, they, in conjunction with the Lithgow and Newcastle steel works, would still be unable to supply the iron and steel required in Australia, if the country were to progress as anticipated.

Heat Treatment of Steel Castings.*

By H. A. Neal, Michigan Steel Casting Company, Detroit, Mich.

The data presented in this Paper were accumulated in the course of an investigation undertaken by the writer at the request of the Electric Steel Founders' Research Group. It was felt that the published information on annealing steel castings was of a very general character, and that it was desirable to determine specifically the proper thermal treatment to apply to electric steel castings of carbon content from 0.20 to 0.32, which constitute the bulk of the Group's output.

In an investigation where the results are to be immediately applied practically, it would seem preferable to do the research work under the same conditions which will be encountered in plant practice. It is obvious, however, that by reason of the expense involved, it is desirable to conduct a preliminary elimination trial under laboratory conditions. That course was pursued, but care was exercised to make the laboratory conditions such that the final results could be checked by actual large annealing oven practice, and applied thereto.

Preliminary Tests of Laboratory Type.

The laboratory apparatus used consisted of a Hoskins muffle-type resistance electric oven, an Olsen tensile testing machine, a Charpy impact machine, and an Upton Lewis fatigue testing machine. All of the above are standard types and need no description. All temperature readings were taken with a Hoskins low-resistance thermo couple and a Hoskins-type P.R. recording pyrometer registering up to and including 1,100 deg. C., both calibrated at the Hoskins plant just previous to the test. After the results on the first 20 bars had been studied, it was decided to eliminate the fatigue tests and rely on the tensile and impact tests.

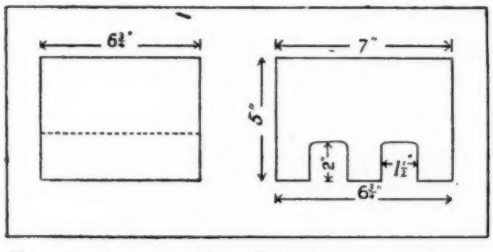


Fig. 1.—Standard Test Block used in Heat-Treating Tests.

To make the results exactly comparable, all the test bars used were cast from a standard pattern, moulded in dry sand and poured from the same heat. The standard test block is shown in Fig. 1. Its dimensions are:—Length, 6 in.; width, 7 in.; height over all, 5 in.; depth of rib, $1\frac{3}{4}$ in.; width of rib bottom, $1\frac{1}{4}$ in.; top, $1\frac{3}{8}$ in. This is the same type of test-block used on both Army and Navy work in the plant with which the writer is connected. All the blocks for the test were moulded in open sand and poured from hand shanks.

The heat from which the test-blocks were poured was a standard acid electric heat worked according to the usual practice at the plant of the Michigan Steel Casting Company. The charge consisted of 1,700 lbs. of foundry heads and gates and 4,350 lbs. of new plate scrap. Additions made in the furnace were 100 lbs. of spiegeleisen, 55 lbs. of 80 per cent. ferro-manganese, and 20 lbs. of 50 per cent. ferro silicon. Twenty pounds of coal were used as a deoxidiser on the slag one half-hour previous to tapping, and the heat was finished under an apple-green slag. No aluminium was added to the large ladle, but one-half ounce per 100 lbs. of steel was added in the hand shanks. The final analysis was carbon 0.27, manganese 0.78, silicon 0.31, sulphur 0.045, phosphorus 0.035 per cent.

* An abstract of a Paper read before the Cleveland meeting of The American Foundrymen's Association.

The test-blocks were lightly covered with sand immediately after being cast, and allowed to cool in the moulds. They were shaken out, sand blasted, and the coupons removed with a band hack saw. The three coupons from each block were stamped with the same serial number. The duplicate tensile test specimens and the impact and fatigue specimens bearing one serial number represent therefore bars from one test-block given one specific treatment.

The sawn coupons were 1 in. thick. In actual practice it would be considered feasible to bring a casting 1 in. in thickness up to annealing temperature in 3 hours. A standard time of 3 hours was therefore adopted for raising from room temperature to 900 deg. C. Experiments showed that the small oven cooled so rapidly that to approximate conditions where an annealing charge is oven-cooled, it would be necessary to retard the speed at which the small oven temperature was allowed to drop. Bars designated as oven cooled have been cooled from annealing temperature to 650 deg. C. at a rate of 80 deg. C. per hour; from 680 to 440 deg. C. at a rate of 220 deg. C. per hour; from 440 to 315 deg. C. at a rate of 110 deg. C. per hour; from 315 to 230 deg. C. at a rate of 83 deg. C. per hour; and from 230 deg. C. to room temperature at a rate of 55 deg. C. per hour. This corresponds to a cooling time of 10 hours in large oven practice.

Essential Factors in Heat-Treating.

The three essential factors in the heat-treatment of cast steel are the soaking time, soaking temperature, and method of cooling. By holding two of these factors constant, the effect of variations in the third can be traced.

Method of Cooling to Obtain Best Properties.

The first series of tests was for the purpose of determining the method of cooling which would impart the best properties to the test bars. For this series the time of raising to temperature was standard, 3 hours from room temperature to 900 deg. C.; the time at soaking temperature was standard, 3 hours, and three standard soaking temperatures were used, 840, 900 and 955 deg. C. For each standard soaking temperature one pair of bars was cooled in the oven; one pair was cooled in the oven to 705 deg. C., and then in air; one pair was cooled in the oven to 535 deg. C. and then in air; and one pair was withdrawn from the oven at full heat and cooled at an unrestricted speed in air.

Results on this series are given in Table I. After a careful consideration of these results, it was decided that the best temperature for a 3-hour soaking period is 895 deg. C. Bar. No. 7 annealed at 840 deg. C., oven-cooled to 535 deg. C., and air-cooled from there down has the highest ductility of the series, but its impact value is low and it falls much below bar 11 in yield point, and ultimate strength. It was concluded that the best method of cooling is freely in air. Withdrawing castings from the oven at 535 deg. C. has no serious effect on ductility, but does affect the impact value. Withdrawal at 705 deg. C. apparently vitiates the heat-treatment.

The Soaking Period.

Having standardised the air cooling, the next step was to determine the effect of a soaking period less than three hours, and the possibility of obtaining equally good results by a shorter anneal at a higher temperature. For this series the time of raising was standard, the time being 3 hours; the method of cooling, freely in air, was standard; and 3 standard soaking temperatures, 840 deg. C., 895 deg. C., and 955 deg. C., were employed. The variable was the length of time the bars were held at maximum temperature.

A study of the results obtained in comparison with Table I., shows that, as the length of time during which the bars were soaked decreased, a higher soaking temperature became necessary to

produce results. In several cases the decrease in ductility and impact figures was noticeable, indicating the desirability of maintaining a 3-hour soaking period for a temperature of 895 deg. C. Others show that the process of heat-treating is as well accomplished by soaking for a shorter period at a higher temperature. None of the bars heated at 955 deg. C. exhibits superior qualities as compared to those heated at 895 deg. C. until the soaking period is decreased to 1 hour.

The Effect of a Secondary Heating on Air-cooled Bars.

The third step was to ascertain the effect of a secondary heating on the air-cooled test-bars. The first series of bars in this section was discarded because of faulty temperature control, and it was necessary to use bars from a different heat, which, however, checked very closely in analysis and tensile properties with the original heat. The analyses were:—Original heat, C 0.27, Mn 0.78, Si 0.31; substitute heat, C 0.28, Mn 0.72, Si 0.35.

The tensile properties on bars soaked for one hour at 955 deg. C. and air-cooled were:—

	Yield point tons per sq. inch.	Tensile strength tons per sq. inch.	Elongation.	Per cent. reduction area.
Original heat ...	19.4	34.3	26.5	40.0
Substitute heat ...	18.0	33.6	29.5	41.0

All the bars in this series were soaked at 955 deg. C. for one hour, cooled freely in air, and reheated to the temperatures given. Maximum ductility was obtained on the bars reheated to 695 deg. C. Above this temperature, as the heating temperature approached the lower critical point, the ductility decreased.

No drawing temperatures below 535 deg. C. were considered, because the discarded set of bars had shown no beneficial results at temperatures below that point.

The fourth section was devoted to ascertaining the effect of oil and water quenching on bars from the standard heat after soaking for one hour at 955 deg. C. Bars were reheated to the temperatures indicated.

The water-quenched bars are slightly superior to those quenched in oil and reheated to the same temperature. It is interesting to note that a bar water-quenched from 955 deg. C. and reheated to 650 deg. C. gave about 49 tons tensile, whereas an air-cooled bar from 650 deg. C. gave only about 31 tons.

Check Tests.

All the work up to this point was done in the laboratory. From the results obtained, certain theories had been formed regarding desirable heat-treating practice in large oven operation. To verify these theories 24 test-blocks were cast on 24 successive heats. The test-bars were removed from the blocks and two bars from each heat were sent to the Lebanon Steel Foundry for heat treatment, while the third bar was heat-treated in the author's plant. The object in making the division was to check results from two different systems of treatment. At Lebanon all the bars were soaked for three hours at 900 deg. C. and oven-cooled. In our own plant one bar was placed on each charge for 24 successive heat-treating charges. The ovens used at both plants were car-type ovens, oil fired, with overhead burners.

At the plant of the Michigan Steel Casting Company, the cars were lightly loaded. Temperature readings were taken with couples on the bottom of the charge so that the pyrometer did not register full heat until the whole charge was heated throughout. The time of holding was taken from the time the charge was heated throughout until the car was withdrawn from the oven at full heat. Section of the castings under treatment ranged from ½ in. to 2 in. The charges consisting of heavier castings are the ones held longer. The bars were placed about one-third of the way down in the charge. Temperature at the location of the bars was from 930 to 940 deg. C.

It was found that, on a majority of the bars, the air-cooling treatment from a temperature in excess of 930 deg. C. produced higher ductility values than oven-cooling from 900 deg. C., in spite of the fact that the soaking time was much less and that no subsequent reheating treatment was resorted to. The analysis range of the bars was purposely made wide enough to show whether any modification of the method of heat-treatment should be made as the carbon increases. Within the range taken there was no marked decrease in ductility in the higher carbon bars, but it is felt that above 0.30 carbon a too-severe air-quenching might necessitate a secondary heating to secure the desired ductility.

Table I.

Table of Physical Properties, Uniform Soaking Period.

Test	Cooling.	No.	Method.	Temp. Deg. C.	Y.P. Tons per sq. in.	M.S. Tons per sq. in.	E. per cent. on 2 ins.	R.A. Per cent.	Impact. foot-lbs.
1	In oven	..	.. ..	840	16.7	31.3	25.0	31.8	17.0
					16.6	31.2	21.5	29.8	
2	In oven	..	.. ..	895	17.3	32.2	26.5	34.1	
					17.5	32.2	28.1	36.6	19.0
3	In oven	..	.. ..	955	16.7	31.3	23.4	29.8	15.0
					16.5	31.4	23.4	29.2	
4	Air cooled from 705	..		840	19.4	33.4	20.3	23.	20.0
					19.5	33.7	20.3	22.7	
5	Air cooled from 705	..		895	20.0	30.5	20.3	22.7	
					19.3	33.3	20.3	24.8	20.0
6	Air cooled from 705	..		955	18.8	34.3	15.6	20.6	17.0
					Test piece too small for grips.				
7	Air cooled from 535	..		840	17.5	32.0	32.8	41.9	
					17.8	31.9	31.2	42.2	18.0
8	Air cooled from 535	..		895	17.4	32.0	26.5	32.5	
					17.9	31.9	29.7	33.4	20.0
9	Air cooled from 535	..		955	17.2	31.9	23.4	26.5	
					17.5	32.1	23.4	29.2	15.0
10	Straight air cool	..		840	20.0	23.3	21.9	24.1	
					19.6	33.4	20.3	21.6	12.0
11	Straight air cool	..		895	20.0	34.3	26.5	34.4	
					19.5	34.2	28.1	07.3	29.5
12	Straight air cool	..		955	18.7	34.0	26.5	32.8	
					18.3	33.6	23.4	30.8	30.0

Conclusions.

The heat-treating research is still being prosecuted, and the problem now is to secure practical application of the information gained experimentally. Having determined the temperature and treatment which will give good commercial results, we must study heat distribution within our ovens to make sure that all castings in a charge receive the same treatment. This implies that due care shall be taken in the location and protection of couples so that the temperatures shown on the recording meter will give a true picture of conditions in the castings of the heat-treatment charge.

We have drawn the following tentative conclusions from our work to date:—

1. Where by reason of the mass of the individual castings or the size of the oven charge, it is necessary to hold the oven at maximum temperature for several hours to ensure heat penetration, that temperature should be 900 deg. C.

2. Castings should either be cooled in the oven to 540 deg. C. or straight air-cooled. No intermediate practice such as cooling to 705 deg. C. and then withdrawing from the oven, or opening the oven doors and allowing the castings to cool at an accelerated rate in the oven, will give desirable physical properties.

3. A short soaking at a fairly high temperature will produce as good results as a longer soaking at a lower temperature, if sufficient time is allowed to ensure heat penetration. For light uniform sections, one hour soaking at 955 deg. C. with air-cooling will yield maximum strength and adequate ductility.

4. High ductility can most surely be obtained by air quenching and reheating to a temperature between 595 and 680 deg. C.

5. By employing oil or water quenching with a suitable draw, physical properties higher than ordinary can be obtained.

Standards for Routine Heat-Treating.

For the guidance of the operating men in the plants of the Electric Steel Founders' Research Group, definite standards have been established to cover all routine heat-treatment.

1. All castings except only such as are stipulated by the customer to be delivered to him in a raw or unannealed condition shall be heat-treated.

2. All castings repaired for cracks, all castings in grade A, and all other castings believed by the makers to be logical substitutions for malleable iron from the standpoint of strength shall be thoroughly heat-treated after welding, even when this necessitates one or more supplementary heat-treatment operations. All castings in any grade shall be thoroughly heat-treated after each welding operation when welding has taken place on a surface to be machined, or on a surface believed by the maker to be relatively important under wear or stress.

3. The maximum temperature (between permissible ranges) employed in every heat-treatment which is intended to produce the desired results without a subsequent heat-treatment, shall be maintained continuously for at least two hours for all carbon steel and alloy steel castings of any composition.

4. The maximum temperature applied to all carbon steel castings not exceeding 0.30 per cent. in carbon shall be no lower than 870 deg. C. nor higher than 900 deg. C. After the required maximum temperature has been applied for the proper time, all carbon steel castings shall either be cooled in the annealing oven to 540 deg. C. or lower before removal from the oven, or be permitted to cool in the air at room temperature immediately after removal from the oven, while the latter is subjected to the prescribed maximum temperature. The maximum limit of 540 deg. C. permitted for the oven-cooling of carbon steel castings shall be determined by pyrometer reading, or by the loss of all temporary reddish colour resulting from heat.

5. For alloy-steel castings and for carbon-steel castings having a carbon content exceeding 0.30 per cent., each group plant shall employ maximum temperatures and cooling operations which, in the opinion of the said plant, are most suitable for the chemical composition and design of the castings.

6. Every heat-treating operation shall be accompanied by the use of a recording pyrometer. All recording and indicating pyrometers shall be periodically calibrated and shall always be maintained in first-class condition.

7. To supplement the use of pyrometers, at least one fracture or bend test-piece of appropriate dimensions shall be placed in every annealer-load subjected to heat-treatment. A sufficient number of such test-pieces shall be placed in every annealing oven at least twice weekly. The purpose of these annealing test-pieces is to determine by degrees of bend or by nature of fracture, or both, the suitability of the temperature actually applied to all castings, whatever be their location or partially insulated condition in the annealing oven as compared with the pyrometer couples.

The writer wishes to acknowledge the assistance of his associates in the American Steel Founders' Research Group.

British Cast-iron Research Association.

Monthly Circular No. 21.

Malleable Cast Iron.—The Research Bulletin No. 3 contains some valuable data on malleable iron, together with micros. obtained from the research work in hand. This preliminary information should show the malleable industry how very essential it is to push forward a wide scheme of research. The present malleable members of the Association will, however, have the benefit of this early information, which will be supplemented in subsequent Bulletins.

A number of firms who are not members of the Association have applied for specific information upon this work; it should, however, be clearly understood that members only are privileged to obtain same.

Cast Iron to Resist Corrosion.—The announcement that a research is to be made into the above has been welcomed by a large number of members, showing the necessity of it being carried out. Interesting data has been sent in by members, from which it is evident that the purposes for which case iron was required to resist corrosion are fairly large; they include piping, ship propellers, submersible motors, submarine junction boxes, electric heating apparatus, ironclad and other switch gear for ship use, ship fittings, pumping plant of all kinds, condensers, turbine cylinders, parts of internal combustion engines, etc.

Such a research will therefore be of great interest and value to all classes of engineers, the corrosion problem, despite many attempts to explain the phenomena, is a long way off being solved. Every support should therefore be given to the Association in this research.

Membership.

New members are now coming along in a very gratifying manner. Over a dozen large firms will be elected at the next election meeting; these, it is hoped, will be further increased by other applications.

Die Castings and Other Matters.

In a recent article it was stated that the proposed research upon die casting alloys to be carried out by the Non-Ferrous Metals Research Association has caused alarm among sand foundrymen. It further states that as die castings have replaced in some uses malleable castings, there is every probability of the ultimate results of the research affecting cast iron generally.

It has been pointed out in these circulars several times that whilst cast-iron foundrymen are up against the keen competition of drop forgings, die castings, etc., they have only themselves to blame if the ultimate result of research in other metals is the elimination of cast iron for the numerous uses it is now employed in.

The work of the Association of necessity moves slowly, at the same time progressively. During, however, the two years of its existence it has, without doubt, stirred up the foundry industry to look upon the necessity of some improvements being carried out to meet the new competition.

The Association by its investigations has created a possibility of a new trade in certain castings. It has investigated melting practice and melting furnace proportions, and are now in a position to advise as to the choice of mixtures, melting procedure and in the fixing of suitable furnace details.

The question of moulding sands has been under investigation for some time, and the Association has collected a vast amount of data and samples respecting the fundamentals of facing and core sand composition and preparation, and are prepared to assist with any problem in connection with moulding.

The standardisation of test-bars has become increasingly necessary. The provisions for such tests is often a matter of moment. The Association is investigating this important matter, and the relative values of tensile, transverse, torsional and fatigue tests are being examined in relation to the design of the class of casting under examination.

XUM

An Apprenticeship Course in Foundry Practice.—LX.

By Ben Shaw and James Edgar.

STEEL FURNACES.—Part I.

The apprentice foundryman, in whatever branch of the trade he is engaged, should endeavour to obtain as extensive a knowledge as he can of general metal melting practice. In the small brass foundry it is much easier to obtain an insight into furnace work than in the iron foundry, and a knowledge of cupola practice is more readily obtained than experience in melting steel. But just as the iron foundry apprentice should learn what he can of cupola design and methods, so should he devote time to the study of steel melting, which presents peculiar difficulties and is more involved because of the higher temperatures necessary.

Crucibles and Crucible Furnaces.

There are four different types of furnaces used for steel melting, these being the crucible furnace, electric furnace, modifications of the Bessemer convertor, and open-hearth furnace. Crucible-melted steel is very superior, and it is still used for some high-grade work, but it is costly to produce and, for this reason, is being substituted largely by the electric furnace. The reason for the superiority over the metal produced in the Bessemer and open-hearth furnaces is that the melting is not done in an oxidising atmosphere. Owing to the high column of coke, associated with a limited supply of air, the gases, instead of containing oxygen which would combine with the metal, actually absorb oxygen. Because of this

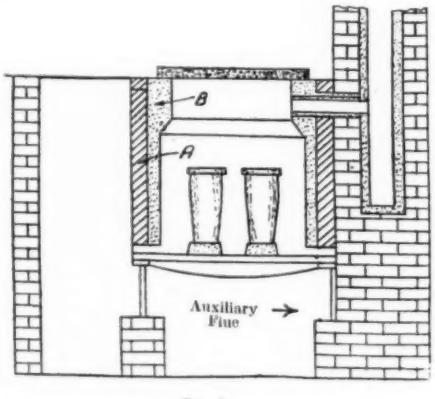


Fig. 1

they are called reducing gases and the melting is done in what is called a reducing atmosphere. There are two types of crucible furnaces, the one type being coke-fired and the other type gas-fired. There is no material difference between the coke-fired furnace used for steel and that used for brass. It has the advantage over the gas-fired furnace in not occupying so much space, but it is not as economical as the gas-fired furnace when a continuous supply of metal is required, because of the ease with which the waste gases of the latter furnace can be utilised for pre-heating the metal. In principle and design the gas-fired furnace is very similar to the open-hearth furnace.

Fig. 1 is a section of a coke-fired crucible furnace. They are usually elliptical in shape, so that two furnaces can be set side by side, and lined with ganister. The furnaces are usually in rows connected to a common flue and the lining is packed with the aid of an elliptical plug of wood, the ganister being rammed round it, after which the plug is withdrawn and the inside of the furnace slowly baked. In the illustration, A represents the first lining of firebrick inside the steel shell and B the ganister lining.

Crucible melting shops very frequently make their own crucibles, clay being the material used. Plumbago crucibles are used, but containing as they do much carbon, the metal absorbs a very small amount which increases its carbon contents, but plumbago crucibles last longer, and in order to make use of them and yet reduce the possibility of the metal absorbing carbon from them, they are sometimes lined with clay. On the other hand clay crucibles cause a slight increase in the percentage of silicon in the steel; whilst this can be obviated by the introduction of a small percentage of hematite in the charge, it is not advised. Generally, however, clay crucibles are used. Most foundries experiment until they find a satisfactory crucible mixture, and then adhere to it. To the fireclay used a small quantity of either coke or coal dust is added. A common mixture consists of 80 to 90 parts of fireclay, two parts of ground hard coke, and the remainder—making 100 parts altogether—of old crucibles broken and ground. Some foundries, on the other hand, use a mixture of Derby, Glenboig and china clays in the proportion of two of Derby to one each of the other clays. To this mixture half of one per cent. of coke dust or charcoal is added. The whole of the constituents are thoroughly ground and mixed and then kneaded either by machine or by treading with the bare feet until a uniform and homogeneous mass is obtained. This is very tedious work, taking several hours, but the more thoroughly the mixing is done the more satisfactory are the results.

The mixed clay is then divided into blocks with a spade according to the size of the crucible desired. These blocks are further kneaded by hand to expel any air that may have been left from the primary kneading. Moulding crucibles is a simple operation. The mould is made of cast

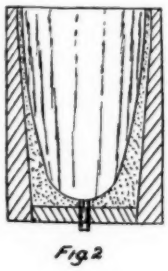


Fig. 2

iron and the core or plug may be either of cast iron or hardwood. By referring to Fig. 2, which shows a section of a mould with plug in position and clay rammed, it will be seen that the loose bottom of the mould has a central hole into which a dowel or pin on the end of the core fits. This guarantees a uniform thickness of clay. A lump of clay is placed in the mould and the core then pressed or hammered down until the pin registers in the bottom plate. This loose plate facilitates the ejection of the crucible from the mould when it can be finished off by hand.

It is very necessary that crucibles should be carefully and thoroughly dried and annealed before using. The method of doing so naturally depends to some extent on the equipment of the foundry, but a drying stove is suitable and shelving may be fixed up over the furnaces. The drying should be extended over several weeks. Before using, the crucibles must be annealed and a special annealing stove is usually installed for the purpose in which the crucible can be brought to a red heat, resting on a grate with the mouth downwards. The coke with which they are surrounded should be small and its sulphur contents should be low. The most common size of crucible are those of 50 or 60 lbs. capacity. They are used for several heats, averaging about four, but with each successive heat the capacity is reduced because of the action of the slag which floats on top of the metal and eats into the crucible, weakening it at that point. A second heat of the same quantity of metal would further reduce the thickness of the crucible and would

probably cause it to collapse. It will be obvious to the student that each successive heat is more costly than the previous one because, while less metal is being melted, the fuel charges are not materially changed.

Fireclay stands and covers are made for the crucibles. The stands should be about 3 in. thick and the cover about 1 in. A piece of firebrick may be used instead of a special stand. When all is ready for charging the crucibles are placed in the furnace on the stands and the fire—medium sized coke being used—built up to the rims. The actual charging is done through long iron funnels, a handful of silica sand being first thrown into the crucible which fills the bottom hole and fuses crucible and stand together. As a rule the charges are made up of Swedish bar, boiler plate, and ship plate, together with shop scrap and hematite, although Swedish bar is frequently excluded. The charge depends very much on the carbon desired in the mixture. When special alloy steels are required steel alloys are introduced in the mixture to give the desired percentage. Beehive coke should be used to prevent injury being done to the crucibles, and the furnace should be well coked, as the temperature must be kept as high as possible. When the furnaceman thinks the charge ought to be melted, he lifts a lid and tries the metal with a rod before adding more coke. The time of melting in a coke-fired furnace varies from about 2½ to 3½ hrs. Gauging the correct casting temperature is not easy, but the orthodox test is to insert a previously heated iron rod into the metal: if it comes out quite clean the metal is satisfactory. Without the iron rod, however, the experienced man can judge very accurately by the appearance of the metal whether or not it is at casting temperature. It is necessary to "kill" the metal before pouring it. This is sometimes referred to as "dead melting" it. During the process of melting gases are generated which are taken up by the metal and are termed occluded gases. These gases are driven off, or at least made harmless, if the metal is kept at a steady temperature for about half an hour after it has reached a casting condition. It is usual to throw a very small piece of aluminium, ferro-silicon and ferro-manganese into the metal to assist in getting a dead melt, the action being that such an addition increases the solubility of the gases and checks the reduction of silicon from both crucible and slag. It has to be remembered that non-metallic inclusions weakens steel and aluminium tends to remain there as alumina, therefore it has to be very sparingly used.

Electric Furnaces.

The electric furnace, which has made great headway during the last ten years, is the most recent method of melting steel for castings. Electric furnaces of various types are used now for steel, iron and brasses. In the very few iron foundries in which it has been installed it is used either as a superheating furnace or for making synthetic iron, and the quality of castings produced is excellent. For the brass furnace special problems have had to be solved and brass founders are not unanimous as to its superiority over coke, oil, and gas furnaces, but for steel melting it is generally recognised as much better than either the open-hearth or converter processes. The steel produced compares favourably with crucible melted steel. In the electric furnace, as in the crucible furnace, the melting is done in a reducing atmosphere.

Before discussing the electric furnace, it will be profitable to explain what is meant by the terms basic process and acid process. Steel furnaces, apart from crucible, must be lined with a highly refractory material which requires to be repaired after each heat and at fairly long intervals to be renewed. In the basic process the lining material is either dolomite or magnesite. Magnesite is magnesium carbonate which has had the CO_2 expelled. It is superior to dolomite as a basic refractory, but it is more costly. It is, however, largely used as a lining for electric furnaces, as it withstands the higher temperatures better. Magnesite is a fair conductor of heat, it is therefore necessary to protect the metal work of the furnace to prevent the magnesite being in direct contact with it. Dolomite occurs as carbonate of lime and magnesia. This material is mixed with dehydrated tar, because of its tendency to absorb moisture. This material is also used for basic converters and basic furnace hearths. The basic process is necessary when it is desirable to remove phosphorus from the charge. The acid process, on the other hand, does not reduce either sulphur or phosphorus, it is therefore very necessary that these elements be kept very low when making up the charge. The furnace lining for this process is silicious and usually consists of silver sand. While either of these processes may be used involving a single slag, the two-slag process in a basic-lined electric furnace is common practice. By this method the process continues as for basic process and when the black slag is removed a second slag is formed by adding lime and carbon dust—usually anthracite, electrodes, or coke. Fluor spar may be added to thin the slag, and this assists in maintaining the basic character of the second slag. This method is instrumental in removing much sulphur from the charge and gives a better quality of steel. The basic furnace is a better refining furnace, which makes it more suitable for alloy steels.

The principle of the construction of many electric furnaces is based on the fact that when any resistance is offered to the passage of an electric current, heat is generated; it is this heat that is used to melt and refine a charge. There are a number of different classes of electric furnaces, but the arc-resistance furnace is most commonly used in the steel foundry. In this furnace the current passes from one carbon electrode to the charge, and through the charge to an electric connection, and so passing from the furnace. The charge really completes a circuit for the current. In some large furnaces more than two electrodes may be necessary. The charge may be molten metal transferred from a converter or open-hearth furnace for refining, but usually it consists of steel scrap. Lime and ore, or lime and mill scale, are used during the process. The electrodes are then lowered until they are in contact with the charge. The electrodes are capable of separate adjustment for this purpose. When the current is switched on, the electrodes are regulated to follow the melting of the charge and to give a constant amperage. When the P. is reduced to 0.01 per cent. the current is switched off and the slag skimmed from the surface of the metal. A second slag is formed with lime, sand, fluor spar and ground carbon in the manner previously mentioned. Before adding it, however, anthracite is added to the bare metal for recarburising purposes. Of this only 40 per cent. is effected. After the slag has been liquefied and furnace conditions stabilised, the composition is built up to specification by adding pig-iron of known carbon content, ferro-manganese and ferro-silicon. Ferro alloys for the production of special alloy steel should be introduced at this stage. The time occupied in producing the steel by the electric furnace will vary according to the capacity of the furnace, but, to give an approximate idea, a 10-ton furnace will melt a charge in about three hours, and the time taken to refine the steel suitable for castings will be about 1½ hours. An additional refining period is necessary for alloy steels.

BETTENCOURT & COMPANY, tinplate and metal merchants, of 82, Princess Street, Manchester, have removed to 3, Marsden Street, Manchester.

GILLESPIES, LIMITED, ironfounders, of Bonnybridge, have established a branch office in Manchester, at 45a, Market Street, under the management of Mr. A. L. Gillespie.

THWAITES BROS., LIMITED, of Bradford, have decided to amalgamate their business with that of Kryn & Lahy Metal Works, Limited, and to carry on the same for the future at the works at Letchworth. This decision will be put into effect as soon as the approval of various interested parties have been obtained. The works of Thwaites Bros., Limited, were originally established in Bradford some 70 years ago, and situated near the centre of the city are very congested, and lack railway sidings, handling facilities and room for extension. The works at Letchworth, which comprise an admirable steel foundry, erecting and machine shops, possess a large site, with ample room for expansion, and enjoy excellent railway and other facilities.

XUM

The Testing of Moulding Sands with Special Reference to Standardisation.*

By C. W. H. Holmes, M. Met., Birtley.

Chemical and Mineral Constitution.

Until comparatively recently moulding sands were universally bought and used on their reputation for producing good castings, which, in view of the lack of fundamental knowledge on the subject, was an excellent proceeding.

Subsequently sands were analysed and the text books stated that moulding sands for steel or grey iron or brass castings should contain so much silica and so much alumina for each class of work, and further that the sand should contain as little lime, magnesia, and alkalies as possible. This again is excellent advice so far as it goes, especially as regards steel castings; but it does not go far enough.

The elementary chemical analysis of a moulding sand indicates the amounts of silica, alumina, lime, etc., which it contains; but the lime does not occur in the sand as quick-lime; it probably occurs in combination with some silica and some alumina as a lime-feldspar.

Again the alumina content is no guide as to the bond of the sand; it may occur in grains of feldspar or it may be combined with silica and water as colloidal clay; the latter is a decomposition product of the former, but their functions in a moulding sand are essentially different.

The next step forward was to group oxides together; and to calculate the "mineral composition" from the chemical analysis. This sets out which minerals existed in the sand and in what proportions they occurred: so much free silica or quartz, so much feldspar, so much clay and so much hydrated oxide of iron.

This, provided that the original chemical analysis was both accurate and complete, brought us nearer to an appreciation of the refractoriness of the sand; for the melting points of the various minerals were known.

But the property of refractoriness is dependent to a large extent upon the size of the particles; the smaller the particles the more readily they frit together and burn on to the casting; causing an unsightly, perhaps unsaleable product and resulting in high cleaning costs.

In order to obtain more information on this important point, chemical analysis has been carried to its logical conclusion, namely the examination of each grade separated from the bulk mechanical analysis.†

Unfortunately the time and money required for such complete examinations—often entailing five complete analyses—is prohibitive as a rule except for research work; consequently but few have been published and definite conclusions are hampered by lack of data.

Before concluding this consideration of our knowledge on the chemical constitution of sands, it will be of use to consider the term clay as applied to the calculated mineral analysis.

Meaning of "Clay."

In calculating such an analysis, the potash (K_2O), soda (Na_2O), and lime (CaO) are each allotted such amounts of silica and alumina as they require and are calculated to their respective feldspars: the remaining alumina is then calculated to clay, all the silica is then recorded as quartz and any iron present is calculated to hydrated iron oxide.

This theoretical clay has the composition $Al_2O_3.2SiO_2.2H_2O$, and approaches more nearly to kaolin or china clay in composition than the more commonly occurring clays.

General experience of clays goes to show that the sticky clays of high colloid content, which form useful natural bonds, depart considerably from such a composition, whilst pure clays which approach the composition $Al_2O_3.2SiO_2.2H_2O$, are more refractory though lacking in bonding properties.

Consequently if one sand contains 5 per cent. of calculated clay and another contains 10 per cent. it must not be assumed that the latter sand is twice as strong as the former.

The reverse might feasibly be as near to the truth.

The importance of hydrated oxide of iron as a bonding medium is now fully realised, but here again the relation between the amount of this substance and its bonding value is variable.

J. E. Fletcher‡ puts forward an interesting hypothesis regarding the constitution of naturally bonded moulding sands. From the consideration of a series of chemical analyses of fine sand, coarse silt, fine silt and clay grades, he deduces that the grain consists of a central nucleus of silica, surrounded by a layer of feldspars, outside which is a further layer of iron and titanium-bearing minerals; whilst the whole is enclosed in a coating of kaolinite (or pure clay substance).

Two objections present themselves against Fletcher's hypothesis; the first is that the feldspars forming the inner jacket must be so finely divided to enable them to be spread around a quartz-nucleus, 1/500 in. dia., that they would be unstable and would be rapidly degraded to kaolinite. The second objection lies in the fact that the inner coating of feldspars is separated by a layer of other material from its decomposition product kaolinite.

It would appear to the writer from his own observations that the following simplification of Fletcher's theory is nearer to the truth:—

(1) That the nucleus of the grains consists of either feldspar or quartz in varying percentages.

(2) That the proportion of feldspar nuclei increases, in the majority of sands, in the finer grades.

(This is what could be expected as feldspars are much more readily attached by natural agencies than are quartz grains. Further, the writer has found that the bond coating contains adsorbed salts, etc.: which especially carbonic or humic acids will hasten the decomposition of the feldspars.)

(3) That a mixed coating of kaolinite (pure clay substance), limonite (hydrated iron oxide) usually; hygragilleite (hydrated alumnia) possibly; and extensively degraded iron, magnesium and titanium bearing minerals covers the nucleus of quartz or feldspar.

(4) That this coating is rarely homogeneous: a thin pellicle or coating usually adheres to the nucleus and cannot be removed by washing.

(5) That it would appear probable that the coating around the feldspars is thicker, richer in kaolinite and more firmly held on the rough semi-decomposed feldspar surface than on the smooth quartz grains.

Our knowledge of the true constitution of naturally-bonded moulding sands is very scanty: and so complex is the subject that our progress must of necessity be somewhat slow.

Mechanical Constitution.

It is doubtful whether mechanical analysis preceded or followed chemical analysis as an early method of examining moulding sands.

On the other hand it is certain that the early work was of limited utility, partly because of the limitation of the apparatus available, and partly because the importance of the mechanical condition of the sand was not so fully realised as it is to-day.

Before proceeding to discuss the methods employed in the mechanical analysis of sands, let us ask ourselves what information we expect to obtain from this test.

From a knowledge of the percentages of sand occurring in the various grades, one can tell approximately whether the sand is suitable for heavy or for light work; if the test is carried out

* A Paper presented to the Paris Congress.

† Boswell. "Memoir on British Resources of Refractory Sands."

‡ J.I.S.I., Vol. 1, 1923. "On Some Characteristics of Moulding Sands."

under certain conditions we can obtain some idea as to the approximate value of the bond, and, most important of all, we can gather some information as regards the venting properties of the sand.

Much general information by inference, but nothing absolutely definite save only the bare statement of the percentages and the grades into which they fall.

Methods Employed for Mechanically Grading Sand.

The methods that have been used for the mechanical analysis of sands are briefly stated below:—

(1) The sand is graded dry, on wire sieves for 30 seconds on each sieve.

(2) The sand is graded dry on wire sieves until no further sand passes the various sieves.

(3) The sand is graded as in method (2) but water is employed to wash the sand through the various sieves.

(4) The sand is graded as in methods (2) or (3), but sieves with round punched holes, 0.2 mm., 1 mm., 5 mm., and 25 mm. diameter are used instead of wire screens.

(5) The sand is graded by methods (1), (2) or (4) and the material passing through the finest sieve is examined by the subsidence test.*

(6) The sand is deflocculated with dilute ammonia by shaking mechanically for one hour. It is then separated into various grades by means of an elutriator, the washed sand grade being subsequently dried and sub-divided by method (4).

Moulding sands consist *essentially* of more or less rounded grains of sand around which some bonding substance is displayed.

Usually they consist of sand grains, silt grains and bond. The bond usually consisting of two portions, one of which adheres firmly to the surfaces of the sand and silt grains, whilst the other, when moistened is capable of further distribution over the surfaces of other grains.

All dry sieving methods show percentages of silt and clay which are lower than the true values, because the very fact that the sand is dry causes much of the silt and mobile bond to adhere to the sand grains. This coating naturally increases the apparent diameter of the sand grains causing many of them to remain on sieves through which they would pass if clean.

Method (1) has but one virtue; it is rapid. So far as the results obtained are concerned, they are so far from the practical truth as to be misleading.

Method (2) is a tedious test to carry out unless a vibrator is used; in any case it suffers from the defects referred to above.

Method (3) is better in that some of the bond coating is removed.

Method (4) removes an inaccuracy inseparable from wire sieves; a round aperture tends to grade to the mean diameter of the grains: a square one to the major axis.

Method (5). Further useful information is here obtained concerning the finest material "200," or the so-called clay grade resulting from the dry sieving.

Method (6). Here deflocculation and shaking separate the bulk into sand grains coated with a very thin and permanent layer of static bond: silt grains, similarly coated: and free particles of mobile bond.

The washing action of the elutriator separates the bulk into its constituent grades with considerable accuracy and check tests agree closely, a most desirable feature which is not always sufficiently appreciated either in routine or research work.†

Crook's elutriator as used by the writer effects separation into the following grades:—

Sand Grade 1 mm. to 0.1 mm. (1/25 in. to 1/250 in.).

Silt Grade 0.1 mm. to 0.01 mm. (1/250 in. to 1/2500 in.)

Clay Grade less than 0.01 mm. diameter.

The separated sand grade is subdivided into *Coarse Sand* <1 mm.> 0.5 mm.; *Medium Sand* <0.5 mm.> 0.25 mm. and *Fine Sand* <0.25 mm.> 0.10 mm. by means of copper sieves with punched round holes.

The silt grade, unless it is so small in amount as to be unimportant is divided in the elutriator into *coarse silt* <10 mm.> 0.05 mm.; and *fine silt* <0.05 mm.> 0.01 mm.

The names and sizes of the grades are of course arbitrary, as indeed they must be in any case, and the writer cannot emphasise too strongly that the really active bonding material is considerably finer than 0.01 mm. (1/2500 in.) in size.

Whilst the elutriation of a washed silica sand would very obviously be a gross waste of time; no other method of mechanical analysis can show us so completely the constitution of "strong" sands, loams and clays.

At the risk of repeating the same thing in another section, the reasons why silt grade and clay grade should not be classed together as "through 200 mesh" or 200 + or clay will now be dealt with.

Silt grades may cause trouble in several respects; mixed with sand grades they choke up the vent, tending to produce blown or scabbed castings; they are invariably richer in chemical impurities than the sand grade, tend to frit more readily and are in consequence liable to cause *burning on* troubles; further, they present a large surface which must be coated with bond if the strength of the sand is to be maintained.

They have only one virtue, they tool well from the moulder's point of view.

In connection with the sieve test it is common practice to multiply the percentages of sand by the mesh numbers of the sieves through which they pass; to add these figures up; divide the sum by a hundred and refer to the result as the *fineness*.

A similar course is pursued in determining the *average grain size* from the sieve test.

Whilst there is, of course, no harm in performing these calculations, their results convey so little—if any—information that they would appear to be a waste of time.

They certainly tell us nothing about the bond nor yet about the refractoriness; and such information as they might appear to convey regarding the venting properties are, more likely than not, to be misleading.

Reference to the work of H. A. Schwartz, and a little thought, should show that sands of similar *fineness* may vary widely in permeability.

It is difficult to see how either the *fineness* or the *average grain size* can ever be of use, either directly to the foundryman or indirectly through the medium of the research worker.

The Nature of the Bond.

In a naturally bonded moulding sand the grains are usually held together by one major factor and two minor ones.

If taking, for example, a shore sand or dune sand, which consists of clean, more or less rounded grains, and moistening it with water, we are able to form it into simple shapes, which fall again to a heap of loose sand as soon as they become dry.

This weak bond is dependent upon the pressure of water and disappears as the water evaporates. It is due to the fact that the surface tension is greater between the water and the sand than between the individual molecules of water.

As this force can only act at the points of grain contact, its magnitude must depend on the number of grain contacts per unit volume; hence the finer the sand and the more irregular the grains are the stronger will this grain become.

This is the only bonding agent used in the casting of pig-iron on sand-beds at the blast furnaces in many cases; principally on account of the difficulty of maintaining any other bond economically under such adverse conditions.

The second minor factor is the *sharpness* (the term is used here to denote angularity, not coarseness) of the grains. Sands composed of angular grains exhibit more surface, more points of contact, and hence greater frictional resistance to deformation than do round-grained sands, size for size.

It must be borne in mind, however, that neither angular grains nor excessive moisture are desirable, and that the bond derived from these sources is slight, and preferably so, in a properly-constituted moulding sand. In the burnt-out silty floor sands, to be found on some moulding floors, it is possible that the two factors discussed above do constitute a considerable percentage of such slight bond as exists. Unless indeed the grains are held together by force of habit.

* For details, see J. E. Fletcher, J.I.S.I., Vol. 1, 1923.
† See appendix: Hatch and Rastall, "Sedimentary Rocks," also Boswell, "Memoir on British Refractory Sands."

The major factor in the bond of a moulding sand lies in the colloidal matter which constitutes a portion of what is commonly known as the *clay*, and also adheres in many cases to the sand and silt grain surfaces.

A full description of the nature and properties of colloids is beyond the scope of so general a consideration as this, and those who are interested should refer to the extensive literature on the subject.

Sufficient to say, that colloidal properties are associated with very small particles and that very small particles possess these peculiar properties because of the enormous ratio of their surface to their mass.

In order that those who have not previously considered this question of the ratio of surface to mass may obtain a clear idea of the subject, let us consider, for example, a cube of cast iron whose side measures 1 in. and whose weight is $\frac{1}{4}$ lb., its volume will be 1 cub. in. and its surface area will be 6 sq. ins.

If it is now split into two halves two new surfaces are exposed, each 1 sq. in. in area, making in all 6 + 2 = 8 sq. ins. of surface exposed, but neither altered the original weight nor the volume has been altered. Hence the ratio of surface to mass has been increased.

If now the cub. in. of cast iron is ground to powder there is still the same weight left at the end of the operation, but instead of having 6 sq. ins. of surface there is something more nearly approaching 6 sq. ft.

The total surface displayed per unit volume of material is known as its *specific surface* just as the weight per unit volume of material is known as its *specific gravity*

Table I. shows approximately the rapid increase of the specific surface of rounded particles as the diameter of the grains diminishes.

Table I.—*Specific Surface.*

Diameter of grains in cm.	Specific Surface in sq. cms.	Remarks.
10.	3.14	
1.0	31.4	No
0.01	314.2	Colloidal
0.005	628.4	Properties.
0.001	3.1416	
0.0005	6.2832	
0.0001	31.416	Colloidal
0.00001	314.160	Properties.

When these particles become so small that one cubic centimetre contains 10 sq. metres of surface (or expressed in English units, 1 cub. in. contains 200 sq. yds of surface) they commence to be of value for bonding purposes.

The bonding materials usually found in moulding sands are known as suspensoids or suspension colloids; their presence can be readily seen by shaking a strong moulding sand with a large excess of pure water. If the water is in sufficient excess (100 times the weight of sand is usually enough) and if the water is sufficiently pure, these minute particles will remain in suspension for an almost indefinite period, rendering the water turbid.

The addition of almost any salt solution to the pure water will cause the colloidal particles to collect into groups of considerable size, which settle out and leave a clear solution.

This phenomenon is known as *coagulation*. The colloidal particles are also capable of attaching to their surface salts and other soluble bodies, and it is by virtue of this property of *adsorption* that one is able to obtain some indication of the amounts of colloidal matter in moulding sands by means of the *dye adsorption test*.

Adsorption usually results in coagulation which, when not desired, may result in erroneous results either in elutriation or in the subsidence test.

An unfortunate lack of knowledge exists as to the properties of the various colloidal substances existing in the bond of moulding sands; and whilst foundrymen are able to produce excellent castings without such knowledge, it is at least possible that one could produce better and cheaper castings were knowledge of the subject more extensive.

For instance, something is known about the mixing of sand grades to obtain the best venting properties, but very little about mixing bonds to obtain the greatest strength and useful life.

The Estimation of the Bond.

Space does not permit of any consideration of organic bonding agents, such as linseed oil, molasses, etc., mineral bonds such as are found in naturally bonded sands will alone be discussed.

Much still remains obscure regarding the chemical and physical properties of these natural bonds.

Originally they were classed as *clay*, but modern investigation has shown that other constituents occur and may be of great value.

How then can we estimate the strength of the bond?

E. W. Smith, in a Paper read before the Chicago Foundrymen's Club, suggests that after sedimentation of the sand with water the bond can be estimated by measuring the height of the layer of clayey matter overlying the column of sand grains.

The writer has shown* that there is little or no relation between the amount and strength of the bond in different sands or even in the same sand in different conditions.

Ashley Franklin, Saunders, Hanley and Simmons have conducted researches on what is now known as the *dye adsorption test*.

This test is based on the fact that certain substances, some of which are dyes such as crystal violet, are adsorbed by the colloids present in the bond.

In practice more dye is added than the bond can take up, the excess is estimated colorimetrically and the amount used (expressed in parts of dye adsorbed per 100,000 parts of sand) is taken as the *bond value*.

The various colloids which constitute the bond have widely different *bond values*, and natural bonds are usually so complex as to render the study of their component parts by this method impossible.

Work carried out by the writer tends to show that the once-despised iron oxide, when colloidal, is the most powerful adsorbent.

The test itself is a lengthy and tedious operation, calling for a certain amount of manipulative skill; discordant results may be obtained unless many precautions are taken, and the test is subject to certain limitations, some of which are given below.

(1) The *bond value* may be considerably altered by mechanical work such as milling; for under these circumstances, while the amount of colloidal matter is not actually increased, the amount so distributed as to be affected by the test is increased and hence a higher bond value is obtained.†

(2) The test is of doubtful value with used sands, as the colloidal matter may be wasted by burnt clay in steel moulding sands, and again in green sands for grey iron, the porous coke resulting from the heating of the coal dust will adsorb dye, giving a positive value on test, whilst it will actually adsorb a certain amount of colloidal matter into its pores, and has, in fact, a slight negative value as regards mechanical strength.

(3) The dye adsorption test can only, under the best circumstances, evaluate the total amount of bond present; it does not tell us how this bond is distributed, and hence gives a poor indication of the true mechanical strength or cohesiveness of the sand, which is the most important practical consideration.

(4) Further, this test takes no account of two factors which have a great bearing on the cohesiveness of the sand, namely, the surface to be coated with bond and the number of grain contacts per unit volume. As already explained, the smaller the grains the greater the surface, and hence the thinner the coating given by a definite amount of bond; this, however, may be somewhat compensated by the fact that the number of grain contacts per unit volume increases along with the specific surface.

(To be continued.)

* J.I.S.I., Vol. 1, 1922.
† See writer, J.I.S.I., Vol. 2, 1922.

Trade Talk.

THE ERECTION of a new foundry and fettling shop in Brighton Road, Croydon, for R. N. Webster & Company, of Purley Downs Road, Croydon, will be started shortly.

ASHWORTH, SON & COMPANY, LIMITED, of the Midland Ironworks, Dewsbury, have removed their London address from 11, Queen Victoria Street, to 78, Finsbury Pavement, E.C.2.

THE new factory at Park Royal of Electrical Utilities, Limited, is now complete, and the company's address in future will be Tudor Works, Park Royal, London, N.W.10.

THE MEN EMPLOYED at Dening & Company's foundry at Chard have agreed to continue working at summertime hours till October 7, the date on which summertime ended last year.

THOMAS BROS., sole agents for the Melingriffith Company, Limited, near Cardiff, have removed from 10/11, Lime Street, London, E.C.3, to 6/11, St. Helen's Place, E.C.3.

THE WAGES of South Wales and Monmouthshire iron and steel workers will be increased next Monday by 6½ per cent. The rate of wages for the concluding quarter of the year will thus be 63⅜ per cent. above the standard.

MR. G. E. MULLINS, of William Jessop & Sons, Limited, Sheffield, has been elected a member of the Transport Committee of the National Federation of Iron and Steel Manufacturers, in place of the late Mr. J. Harrison, of Hadfields, Limited.

SIR MONTAGUE BARLOW (Minister of Labour) met representatives of the Shipbuilding Employers' Federation, the Federation of Engineering and Shipbuilding Trades, and the Boilermakers' Society, last week, and discussed with each the dispute which resulted in the lock-out of the members of the Boilermakers' Society.

TO DEAL WITH INCREASE IN BUSINESS, and to give improved local service, the Brush Electrical Engineering Company, Limited, Falcon Works, Loughborough, have opened offices at Sheffield and Birmingham. The Sheffield office is under the management of Mr. C. E. Brotherton, at 32, White Building, Fitzalan Square, and the Birmingham office is under the management of Mr. Malcolm Brown at Phœnix Chambers, Colmore Row.

A MEETING of the Institution of Welding Engineers will be held at the Holborn Restaurant at 8 p.m. on October 10, under the presidency of Sir W. Peter Rylands, J.P., at which two papers, one on Electric Welding and the other on Gas Welding will be read. These papers are expected to present some novel features. Tickets of admission can be had on application to Mr. C. Raggett, the hon. secretary, at 30, Red Lion Square, Holborn, London, W.C.1.

THE NATIONAL COUNCIL OF THE AMALGAMATED ENGINEERING UNION, at a meeting at Birkdale, passed a resolution that in view of the fact that the Union, through the industrial depression, had paid out over £4,000,000 in benefit to its members, and that 16 per cent. of the membership were still unemployed, the Government should put in hand and assist in the development of projects of public utility for the purpose of finding employment for skilled mechanics.

Gazette.

A RESOLUTION for the voluntary winding-up of the Midvale Steel Company of Philadelphia and London, Limited, has been passed, with Mr E. E. Lloyd, 26, Victoria Street, S.W., as liquidator.

A RESOLUTION for the voluntary winding-up of the Engine Equipment Company, Limited, has been passed, with Mr. A. N. D. Smith, 7, Laurence Pountney Hill, E.C., F.C.A., as liquidator.

THE PARTNERSHIP heretofore subsisting between Messrs. W. C. Tonks and J. W. Pendleton, metal merchants, 28, Martineau Street, Birmingham, under the style of Tonks & Pendleton, has been dissolved.

VAUXHALL ALUMINIUM MANUFACTURING COMPANY.—Messrs. A. J. Clemmons and F. Clews, 148, Francis Street, Birmingham, manufacturers have dissolved partnership. Debts by Mr. F. Clews, who continues the business.

TRADING IN THE STYLE of Hollingworth & Main, Messrs. G. H. Main and F. Hollingworth, Field Hill, Batley, millwrights and engineers, have dissolved partnership. Debts by Mr. G. H. Main who will carry on the business in partnership with Clifford Turner under the same style.

Company News.

Still Engine Company, Limited.—Adverse balance, £21,944.

British Aluminium Company, Limited.—Dividend on ordinary shares, 5 per cent. per annum, less tax.

Craig Engineering Company (Glasgow), Limited, 36, Smith Street, Kinning Park, Glasgow.—Capital £1,000 in £1 shares.

Thomas W. Ward, Limited.—Interim ordinary dividend, 2½ per cent.; final ordinary dividend, 5 per cent., making 7½ for year, all free of tax.

Non-Ferrous Die Casting Company, Limited, 65, New Broad Street, London, E.C.—Capital £5,000 in 3,000 preference and 1,950 ordinary shares of £1 and 1,000 founders' of 1s.

William Cole & Sons (1923), Limited, 71, Hammersmith Road, London, W.14.—Capital £20,000 in £1 shares (10,000 8 per cent. cumulative preference). Engineers, etc. Permanent directors: A. E. Cole (managing director), L. L. Harris and S. C. Jones.

Partington Steel & Iron Company, Limited.—Profit, £258,579; interest, £143,463; brought forward, £24,106; disposable balance, £282,685; dividends on preference shares, 6 per cent. per annum, £21,000; no ordinary dividend; carried forward, £261,685.

Institution of Engineers-in-Charge.—Councillors: H. S. Hele Shaw, W. McLaren, H. Riall Sankey, A. W. Wyatt, J. R. Manning, J. E. Watkins, A. J. Adams, W. H. Patchell, H. B. Fairlie, W. R. Langford, A. T. Penn, S. Carter, A. Arnold, C. A. Pickles, H. A. Murray, C. E. Acock, J. M. Dawson, H. G. Wellington and P. H. T. Morris.

Dalmellington Iron Company, Limited.—Profit, £64,047; brought forward, £6,874; depreciation and deferred repairs, £21,727; preference shareholders 5 per cent., £6,500; ordinary shareholders, 6d. per share (interim), £6,825; general reserve, £15,000; final ordinary dividend, 1s. per share, making 7½ per cent. for year), free of tax, £13,650; carry forward, £7,219.

Obituary.

MR. C. F. DIXON died at Raventhorpe, Darlington, last week, aged 54. He was managing director of the Cleveland Bridge & Engineering Company, Limited, Darlington, one of the largest bridge building firms in the world. A native of Sheffield, he went to Darlington 41 years ago, and made the development of the concern his life work. The company have built some of the largest bridges in the world, including the Zambesi Viaduct. He also commenced the Cleveland Car Company twenty years ago.

MR. W. LATIMER, one of the best known public men of Winlaton and Blaydon, died at his residence, Hollyhurst, Winlaton, recently. Mr. Latimer, who was in his 56th year, was a member of the firm of Robert Bowran & Company, Limited, engineers and paint manufacturers, of St. Nicholas's Buildings, Newcastle, and had been associated with that company for the past 30 years, for the last 14 years as a director. He was well-known in trade circles, being a member of the Mining Institute, and of the North-East Coast Institute of Engineers and Shipbuilders.

Personal.

MR. JOHN BARR has resigned his position as commercial manager of the Barrow works of Vickers, Limited, after forty-nine years' uninterrupted service. The directors, in recognition of Mr. Barr's long and distinguished service, have invited him to retain his seat as a special director of the company, and also to continue to represent them on the board of the Iron Trades Employers' Insurance Association, both of which appointments Mr. Barr has accepted. The resignation has also been accepted of Mr. J. C. Fergusson, the works secretary, and Mr. Barr's chief assistant.

Wills.

YATES, ROBERT PERKS, of John Yates & Company, edge tool manufacturers, Aston ... £27,001

TRAHERN, THOMAS, of Walsgrave-on-Sowe, proprietor of the Aluminium Castings Foundry, Coventry ... £5,163

JONES, GEORGE, J.P., of Meadowcroft, West Hartlepool, managing director of William Gray & Company, Limited ... £209,593

DEXTER, J. L., of High Wycombe, Bucks., managing director of Dexter & Company, Limited, engineers and manufacturers ... £6,972

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The position in the Cleveland iron trade remains practically unchanged as regards the general conditions of the industry, though the tendency of market movements again inclines to a further weakening in values. This process, which has been in operation for some time past, has been very gradual, production at furnaces having been limited to the scope of demand to avoid any violent fluctuations in values, with the result that stocks of No. 3 G.M.B. are at the moment relatively small. It may be of interest to note that a project for reopening the old warrant stores has been recently under discussion in Tees-side iron trade circles, but having regard to the present limited output, and the general commercial outlook opinion is sceptical as to its realisation in the near future. Buying in the meantime is still confined to dealings for immediate requirements, very little forward business being reported, and the disposition all round is rather to mark time. With regard to current values, makers are apparently not indisposed to negotiate where firm offers are concerned, and prices incline to vary according to the business offering. A general quotation for No. 3 G.M.B. is 96s. 6d. per ton, but 96s. would probably be taken for suitable business. No. 1 remains at about 102s., No. 4 foundry is 91s. to 91s. 6d., and No. 4 forge round about 89s. to 90s. per ton.

In the East Coast hematite market an improving tendency may be noted, with a better home demand and Continental inquiry. But there is very little approach to steadiness in demand anywhere, and the position is difficult to gauge. Quotations are irregular. Some makers are still holding out for 100s. per ton for East Coast mixed numbers, but the more general figure is 99s., and it is still possible, for substantial business, to get on at 98s. 6d. The No. 1 quality is round about 100s. per ton. The position in West Cumberland and North Lancashire may be reported unchanged, quotations for Bessemer mixed numbers still ruling at 110s. per ton, delivered Sheffield.

MANCHESTER.—Demand for pig-iron in this market continues on a restricted scale, reports from local foundrymen suggesting that business with them is rather worse than better. Most of them are very indifferent about buying foundry pig, and this is not surprising, seeing that they can buy good scrap at 20s. per ton less money. The report that the demand for Cleveland iron at 97s. on trucks is increasing may perhaps be connected with the fact that Midland iron at 92s. 6d. is no cheaper up in the North than Cleveland at 97s. At present, however, there is a dead level of prices, and but very little variation can be found in the quotations, although it is said that all Derbyshire makers do not adhere very strictly to the theoretically lowest price of 92s. 6d. per ton on trucks. There is, however, so little forward buying that sellers do not have much inducement to compete with one another by cutting prices.

THE MIDLANDS.—Pending the forthcoming quarterly meeting, business in the South Staffordshire area continues in very moderate volume, buyers of pig-iron especially preserving an attitude of reserve, though much less is heard just now of any further closing down of furnaces in the district. Markets, consequently, present a firmer appearance, and hopes are now entertained that the slump predicted in the coming winter months may be averted. Smelters have not yet regained control of the market, but when they do it is definitely certain that higher prices must rule, unless, in the meantime, there has been an appreciable reduction in production costs, which remain disproportionately heavy. Apparently, however, there is no present prospect of a reduction in fuel. It is reported that there has been another conference between coke-oven and blast-furnace proprietors, without the price being altered. Quotations:—Northamptonshire No. 3 foundry, 90s.; Derbyshire No. 3 foundry, 92s. 6d., all net f.o.t. furnaces.

SCOTLAND.—Some slight improvement may be reported in the Scottish pig-iron market of late, though the actual volume of business transacted is still, of course, much below normal proportions. There is, at all events, some acceleration in the forward-buying movement, and though the quantities involved are not large the tendency inspires confidence that a turn for the better is impending. With stocks in consumers' yards so low, a general buying movement would be quickly reflected in an advance in prices. No. 3 Scotch is unchanged at 100s. at furnaces, although for a substantial line this price could be broken. The demand from abroad is fairly well maintained, and No. 3 is quoted at 105s. f.a.s. Glasgow. No. 3 Middlesbrough is on offer at 100s. at Grahamston, but the Cleveland makers seem disinclined to make further concessions.

Finished Iron.

Although markets for finished materials in the chief centres of the trade are well attended, business in most departments remains in a lethargic condition, and many works in the country are practically idle from lack of orders. The single exception, perhaps, is found in the marked bar section, which maintains its steadiness, while mills and forges generally are but poorly employed. The present slackness may be in part explained by the displacement of iron by steel, by reason of the comparative cheapness of the latter material for many constructional purposes. Prices of finished material also remain at too high levels owing to inflated costs of production, and until some readjustment is effected the present conditions of the trade cannot possibly be improved.

Steel.

The depression previously reported in the industry has undergone no improvement so far, manufacturers with few exceptions complaining of continued lack of orders, while the volume of fresh inquiries is also disappointing. At Sheffield this unsatisfactory state of affairs is evidenced by the further slowing down in the buying of semi-products of all kinds, not even the cheaper grades of basic billets being bought on any substantial scale, while for acid qualities business is all but at a standstill. Bessemer and Siemens acid are both maintained at £12 10s. delivered, while for basic, soft are quoted at £8, medium £10, and hard £10 5s., delivered Sheffield. There is stated to be a slightly better demand for bright steel bars at £15. For Sheffield's high-quality steels some inquiries are about, and in one or two cases orders have been placed, but on the whole the immediate prospect for manufacturers is by no means cheering. Naturally, the present conditions have affected the sale of ferro-alloys and materials required for consumption in the manufacture of steel and steel products, and there is little actual business done that can be reported. The situation in ferro-manganese is much the same, with British prices unchanged. In the tinplate market recently there has been quite a good inquiry, and a very fair proportion of business has resulted. Requirements, however, are almost entirely for delivery as early as possible, buyers not caring to commit themselves ahead to any extent. Current quotations rule as follows:—Coke tins—IC 14 by 20, 112 sheets, 108 lbs., at 23s. 1½d. per box; IC 28 by 20, 112 sheets, 216 lbs., at 46s. 3d. per box; IC 28 by 20, 56 sheets, 108 lbs., at 23s. 7½d. per box, with light weights at 3s. 4d. per lb. reduction, net cash, f.o.b. Bristol Channel ports,

Scrap.

Broadly speaking, there is not much improvement to note in conditions as far as scrap metals are concerned, and business continues on a contracted scale, due, it must be assumed, to the depression now existing in the foundry industry. In the Lancashire area, for example, the demand is very slow, with the selling prices for cast scrap varying from 75s. to 85s. per ton, according partly to the district and partly to the quality. In the Manchester market quotations rule about 85s. per ton for the best lots of broken textile-machinery cast-scrap; but the more general prices for good ordinary scrap in most parts of the country range from 75s. to 80s. per ton. In Scotland the steelworks are still taking in small quantities of turnings, but their consumption is reduced considerably. Cast-iron borings are quoted about 63s. The inquiry for cast-iron scrap is still fairly strong, and it is exceedingly difficult to secure supplies. Delivery is therefore somewhat slow, and a number of the works are pressing for more regular despatches. Heavy machinery cast-iron scrap and scrap railway chairs run around 95s., and ordinary cast-iron scrap 82s. 6d. to 85s. Light metal and furnace firebars are 65s.

Metals.

Copper.—Business in the standard market of late has evidenced some irregularity due in a measure, doubtless, to developments in America, where further weakness has been disclosed. A steadying factor in the position has, however, been provided by speculative buying on outside account, which, though at present on a limited scale, indicates a growing interest in market movements of the metal. Home consumptive demand is on a fairly steady scale, while the

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SIZE	* Size of Moulding Box.	Straight Pattern Draft.	Nett Weight of load that can be rolled over at 80lbs. pressure.
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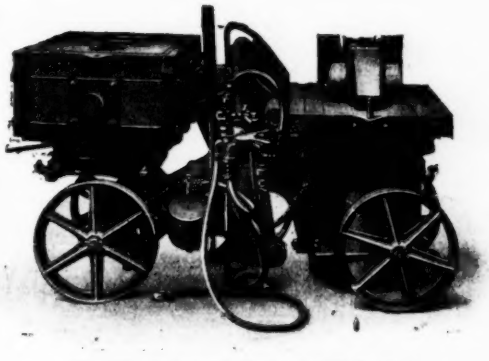

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METAL MARKETS—*continued.*

forthcoming monthly statistics are anticipated as favourable to further expansion of business. Current quotations :—*Cash* : Thursday, £62 15s. ; Friday, £62 2s. 6d. ; Monday, £62 5s. ; Tuesday, £61 12s. 6d. ; Wednesday, £61 7s. 6d. *Three Months* : Thursday, £63 5s. ; Friday, £62 10s. ; Monday, £62 15s. ; Tuesday, £62 5s. ; Wednesday, £61 17s. 6d.

Tin.—Movements in this market during the past week have been somewhat erratic, values fluctuating within an exceptionally wide range, but closing slightly above the lowest previous level. Recent movements are chiefly due to sales by weak holders, and to the release of 2,000 tons of the reserve stocks held by the Federated Malay States. The States have been holding a stock of about 10,000 tons for the last two years. In April last they made an agreement with other large holders in the East to sell no more than 5 per cent. of their reserve stocks every month. All other parties to the agreement have been selling their allotted quota since April. The F.M.S., however, allowed their quota of 500 tons a month to accumulate. This enabled the Government to dispose of 2,000 tons at a price of over £200, instead of at the much lower figure which has generally ruled during the last four months. Indeed, the price has been as much as £25 a ton lower in the interim. Current quotations :—*Cash* : Thursday, £198 10s. ; Friday, £199 ; Monday, £202 15s. ; Tuesday, £202 ; Wednesday, £200 17s. 6d. *Three Months* : Thursday, £198 10s. ; Friday, £198 15s. ; Monday, £202 ; Tuesday, £201 7s. 6d. ; Wednesday, £200.

Spelter.—The market for this metal remains quiet but steady, with little change in values for the week. Rudolf Wolff & Company report that Continental producers are holding for higher prices, and there is no sign of stocks accumulating to any appreciable extent. The market in the United States of America remains quietly firm, and prices ruling steadily above London parity, export sales have not been practicable. Current quotations :—*Ordinary* : Thursday £33 5s. ; Friday, £33 ; Monday, £32 17s. 6d. ; Tuesday, £33 ; Wednesday, £32 15s.

Lead.—The market for soft foreign pig has shown a weaker tendency of late, the anticipated demand for reconstruction purposes in Japan not having, so far, materialised. Supplies are forthcoming in substantial volume, and, although consumption in this country continues to absorb them in surprisingly good fashion, it is not on such a scale as to make for any shortage. The market closed steady. Current quotations :—*Soft foreign (prompt)* : Thursday, £26 5s. ; Friday, £26 5s. ; Monday, £26 7s. 6d. ; Tuesday, £26 5s. ; Wednesday, £26 7s. 6d.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Selling Pig-Iron on Analysis.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I should like to refer to the note on the above subject by Mr. Young in your issue of September 27.

Although there are distinct indications of improvement on the part of a few pig-iron makers, it must be admitted that the position is still far from satisfactory. There is, however, no need for foundries who wish to control their iron to wait till the iron masters of this country have put their house in order. If discriminating foundries insist on *buying to analysis* the desired improvement will be hastened.

To this end I would suggest :—

1st, That advertised analyses be ignored. The same series of analyses frequently appears, complete to three decimal places, without alteration from year to year.

2nd, When sending out inquiries for pig-iron, limits of composition should be fixed. Naturally these limits should be made as wide as permissible for the class of work in hand. It is also well to invite the makers to say wherein their iron differs from the specification, should they be unable to meet it. A maker may possibly have a consignment low in manganese which can be used by a foundry which happened to have in stock some high-manganese pig-iron.

3rd, Stipulate rigidly that if the consignment does not come within the limits agreed on it is liable to be rejected.

4th, If the iron, after careful sampling in presence of both buyer and seller, and analysis by an accepted referee, does not comply with the specification, it should be sent back at the cost of the seller. It is no more unreasonable to send back a load of unsuitable pig-iron than it is to return a quantity of $\frac{5}{8}$ in. bolts where $\frac{3}{4}$-in. bolts have been ordered. The buyer of the pig-iron has to bear the cost of unloading and reloading at his works. This in itself should be a sufficient safeguard against rejection of a delivery without sufficient reason.

As regards the specification itself, undernoted is a specimen showing the nature of the limits which I consider sufficiently close for a foundry doing average work, and yet sufficiently wide for iron makers :—

Total carbon, not over 3.5 (if possible) ; silicon, 1.3 to 1.9 ; manganese, over 0.8 ; phosphorus, under 0.7 ; and sulphur, under 0.08 per cent.

The total carbon content is not rigidly specified. I find that some makers of ordinary pig-iron can regularly deliver within these limits, while in higher quality pig, much more stringent requirements, such as low total-carbon, silicon, phosphorus, sulphur and high-manganese can be made.

If the routine analysis after delivery does not agree with the specification, the procedure adopted is as follows :—

1st, Repeat analysis of the routine sample.

2nd, If this confirms the first analysis, take a fresh sample.

3rd, If this second sample is also not within the specification send a portion of it to the maker. If the maker's analysis confirms the buyer's, and provided the maker has confidence in the fairness of the sample, the dispute often ends at this stage, because the maker has probably discovered how the wrong iron came to be sent.

4th, Should the maker still be at a loss to explain the error he should be invited to send a representative to witness the taking of a sample. Portions of this sample should then be handed to the buyer and the maker, and a third portion sent to the referee.

Concerning the actual analysis, Mr. Young states that "few reliable analyses of cast iron or pig-iron are issued from the average laboratory." There is little excuse for this state of affairs now that standardised samples are available for taking processes, and I cannot say that my experience confirms Mr. Young's statement.—Yours, etc.,

JOHN ARNOTT, A.I.C.

The Laboratory,
Messrs. G. & J. Weir, Limited,
Cathcart, Glasgow.
September 29, 1923.

[This does not meet the case of the small foundries having no laboratory, who have to rely on the maker's analyses.—EDITOR.]

Contracts Open.

Carmarthen, October 15.—Gas works' plant, for the Joint Counties Mental Hospital, Carmarthen.—Particulars, Mr. W. J. Wallis-Jones, clerk to the Visitors' Committee, 34, Gray Street, Carmarthen.

Leeds, October 13.—Ironfounders' work, for the Town Council.—Lewis, Chorley & Gribbon, 3, Park Place, Leeds.

Stourbridge.—Supply of nine tons of 3-in. cast-iron pipes, for the Stourbridge and District Water Board, Worcester.—Mr. W. B. Cleverly, engineer and manager, Hagley Road, Stourbridge.

Blast Furnace Valuation in Ayrshire.—Before the County Valuation Appeal Court at Ayr, the Dalmellington Iron Company appealed against the valuation of their five blast furnaces at 2,000 and of the ammonia works at £1,900. Mr. Dalrymple, the manager, stated that the furnaces had been out of blast for 2½ years, and owing to the continued depression in the iron and steel trade they saw no possibility of putting them into blast for some time. They had suggested dismantling the works, but the Assessor would not say what he would accept by way of dismantling. The firm were very loth to demolish any part of the works, because they hoped that at some time or other they might be able to restore the furnaces, although geographically they were not well placed for the manufacture and disposal of pig-iron. The Court agreed to reduce the valuation to the pre-war figure, viz., blast furnaces, £1,500 ; ammonia works, £1,750.